ROAD CONSTRUCTION
GENERAL SPECIFICATIONS

NATIONAL BOARD OF PUBLIC ROADS AND WATERWAYS 1969

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R O A D C O N S T R U C T I O N

GENERAL SPECIFICATIONS

CONSTRUCTION OF ROAD FORMATION: EARTH 1500

1969

ROAD CONSTRUCTION
General Specifications

C O N S T R U C T I O N O F R O A D F O R M A T I O N :
E A R T H 1500

CONTENTS

GENERAL

The construction of road formation in earth shall be carried out as set forth on the Plan. Materials shall be used in the best way from the point of view of both construction economy and of construction technique.

During the construction of road formation in earth regular tests shall be made as to the quality of excavated soil or borrow materials. Should there be deviations from the Plans, the thickness of the road formation shall be adjusted accordingly both at embankments and in cuttings.

1510 EXCAVATION IN EARTH

G e n e r a l

Prior to the start of excavation operations measures shall be taken to carry out all preliminary works specified in Item 1100 of these Specifications and to set out necessary dimensions as set forth in Item 1100...9300 "Common Works".

The dimensions given for cuttings on the Plan are minimum dimensions.

Great care shall be taken in excavation operations in order not to cause damage to vegetation outside the excavation area.

When frost-susceptible, erosive soils are excavated and when required by slopes of the terrain, the use of back ditches shall be considered, and necessary ditches shall be excavated as early as possible.

Should there be two or more soil types in the cutting, the grade of slopes and the thickness of the road pavement shall be determined on the basis of the weakest soil type. On dual carriageway roads the thickness of the road pavement shall be determined for each carriageway separately.

Excavation should be carried out in such manner that ditches and slopes are excavated at the same time with an exception of weak areas. Excavating ditches simultaneously with other excavation operations will facilitate the drainage of the bottom of the cutting.

Should the soils be muddy, the bottom of the cutting may be constructed to a larger crossfall during the construction work in order to facilitate drainage. In that case the bottom of the cutting shall be brought to the final crossfall and elevation before the road pavement is laid.

At frost-susceptible cuttings in which the bottom is rich in stones, the thickness of the road pavement may be increased upon consideration. At frost-susceptible cuttings, the Employer shall make random tests to ensure that there will be no rock closer than the depth required by the transition wedge (1,6 ; 1,8 or 2,0 m) to the road surface. Should there be rock above this depth, directions given in connection with transition wedges shall be followed. At locations remaining underneath the road pavement, the bottom of the cutting shall be compacted to a uniform condition in conformance with the requirements specified for the upper portion of embankments.

T r a n s i t i o n W e d g e s

Transition wedges shall be constructed to even out the differences in the freezing and bearing properties of the subgrade and to diminish any detriments resulting from uneven frost heave and settlement. On road with Road Pavement Categories 1, 2, 3 and 4 transition wedges shall always be built as specified on the Plan and/or on Design Drawings attached (Appendixes 1...9). As for bridges, see the embankments near special structures. On lower-class roads, the use and the structure of transition wedges shall be considered separately for each case. In cases where the transition is from rock to weak soil, a transition wedge shall always be constructed.

In the Road Districts of Uusimaa, Turku, Häme and Vaasa, the depth of the transition wedge to be made at the boundary of frost-susceptible and frost-resistant subgrade shall generally be not less than 1,6 m, in the Road Districts of Kymi, Mikkeli, Pohjois-Karjala, Kuopio, Keski-Suomi and Keski-Pohjanmaa 1,8 m and in the Road Districts of Oulu, Kainuu and Lappi 2,0 m measured from the road surface. The depth of the transition wedge at the boundary of rock and frost-resistant subsoil shall generally be 1,0 m. The depth of the transition wedge at the boundary of

frost-susceptible cutting and frost-susceptible embankment shall be 1,25 m. Materials of filter and/or sub-base courses shall be used as backfill materials. If in the latter case the wedge is filled with frost-susceptible fill, the depth of the transition wedge shall correspond to the regional depth and the fill material shall be of uniform quality.

The difference between the slope of the underside of the transition wedge and the principal longitudinal profile, that is, the slope of the wedge in the longitudinal direction, shall be generally 1:30 on motorways and on roads of Ist and 2nd Class and 1:20 on roads of the 3rd and the 4th Class. If the importance of the road is small, transition wedges on Class II roads may be constructed to a slope of 1:20 and on Class III and IV roads to a slope of 1:15, if required by economic reasons. If the slope of the principal longitudinal profile to the ground surface is flatter than that above, no transition wedge is needed. A transition wedge on frost-resistant subgrade may be constructed to a slope steeper than specified above.

The underside of transverse and longitudinal transition wedges shall generally have the same crossfall as a subgrade of the corresponding bearing category with the exception of transition from frost-susceptible cutting to frost-susceptible embankment, in which the transverse crossfall may be $\leq$ 1:10, if normal embankment fill is used.

In areas where a normal transition wedge is not built, the road pavement shall be made thicker in a length of 5 m over a subgrade with a higher bearing capacity (Appendix 9).

Mineral aggregate for filter, insulating and/or sub-base courses may be used in the construction of transition wedges. If backfilling shall be directly onto rock, or when the wedge runs into a stone embankment, broken rock may be used. In that case, however, specifications for the construction of stone embankments shall be observed. The portion of transition wedge in junction with a rock cutting, the purpose of which is to reduce the effect of the steep rock wall, shall be constructed, depending on the depth of the wedge, either of broken rock or of coarse stone chips or of crushed stone. When coarse material is used as fill on fine-grained subsoil, there is the risk that the fine-

grained material will penetrate into the fill. A filter and/or insulating course, depending on the quality of subsoil, shall therefore be laid underneath the fill.

As a rule, the drainage of a normal road pavement is sufficien also at a transition wedge. If necessary, such a subdrain may be laid at the bottom of the wedge as has a structure capable carrying the load of traffic. The subdrain shall be laid on th surface of subsoil in such manner that it will collect water from the road pavement courses but not from subsoil.

Compacting shall be performed in such manner that the density of the transition wedge will be that specified for the upper portion of an earth embankment. The line of slope of the trans ition wedge shall be parallel with the road. In transition fro frost-susceptible cutting to frost-susceptible embankment, whe frost-susceptible fill is used, the line of slope may be in an oblique position to the road. Design Drawings have been prepar for single carriageway roads, but they can also be applied for dual carriageway roads, since the transition wedges of each carriageway shall be determined separately.

Should rock be found on frost-susceptible subsoil above the depth of the transition wedge, the frost-susceptible subsoil shall be removed over the full width of the carriageway down to the depth required by transition wedge, and transverse and longitudinal wedges shall be constructed as set forth on the Drawings. If the rock is small, it shall be completely removed down to the depth required by the wedge and the cavity shall b filled with surrounding material. Compacting shall meet the sity requirements specified for the surrounding area.

Should the road be constructed on subsoil with highly changing freezing and bearing properties, or if any local water-bearing strata are encountered which cannot be removed and which will probably cause differential frost heave, transition wedges sha be formed to the depth specified for transition from rock to frost-susceptible subsoil. Should the frost-susceptible soil occur in localised pockets etc., the frost- susceptible materi shall be entirely removed down to the depth required by trans- ition and replaced by frost-resistant material.

Transition wedges at culverts and other similar structures sha

be constructed in conformity with the above principles. The depth shall be the same as in wedges near rock, that is, 1,6 m, 1,8 m or 2,0 m.

If considered necessary, transition wedges may be replaced by earth boxes or heat insulation courses.

Broken Rock and Stones

Broken rock areas shall be excavated in conformity with directions given above for excavation in earth. Stones in cuttings shall be broken and used in embankments, backfills in replacement of soil or in other structures. As regards stones at the bottom of cuttings and rock above the depth required by transition wedge, directions given in Item 1510 "General" and "Transition Wedges" shall be followed.

Slopes

The junction of the ground surface and the slope shall be rounded off. In transition from embankment to cutting, the gradient of the slope shall be changed near the transition spot in such manner that a gentle transition is obtained. Transition from one gradient of slope to another shall be made in conformity with the minimum dimensions given in Item III-1.33 of the Standard Specifications and Instructions of the National Board of Public Roads and Waterways unless otherwise indicated on the Plan. The ends of rock cuttings shall be rounded off and covered and, if necessary, provided with plantations in order to obtain a good result from the point of view of appearance.

Larger stones in earth cuttings and unsightly dangerous rocks shall be blasted to the depth required by facing and broken rock shall be removed to such extent that the slope may be soiled. In certain cases, however, unbroken stones may be left in the slope provided they are not dangerous to traffic. Particularly at spots where there are stones on the original ground surface, it may be practical from the point of view of appearance to leave such stones in the upper portion of the slope.

Should there be unsightly small rock, stone or earth heaps in the lower portion of the slope with normal gradient, such heaps shall be removed and rounded off to a level 1,0 m from the road

surface and faced in compliance with separate directions.

In excavating slopes to be faced, allowance shall generally be made for such facing. Topsoil layer required in grassing will not call for such special allowance.

The slopes shall be constructed with such accuracy that there will be no visible unsightly irregularities.

Flattening and Benching of Slopes to Increase Stability

Flattening and benching of slopes shall be carried out as specified on the Plan. The tops and toes of slopes shall be shaped as specified for the slopes in cuttings.

Unless otherwise specified, the subsidiary and main excavation shall be carried out first down to the level specified for benching and then the remaining part of main excavation shall be completed.

Construction in Winter

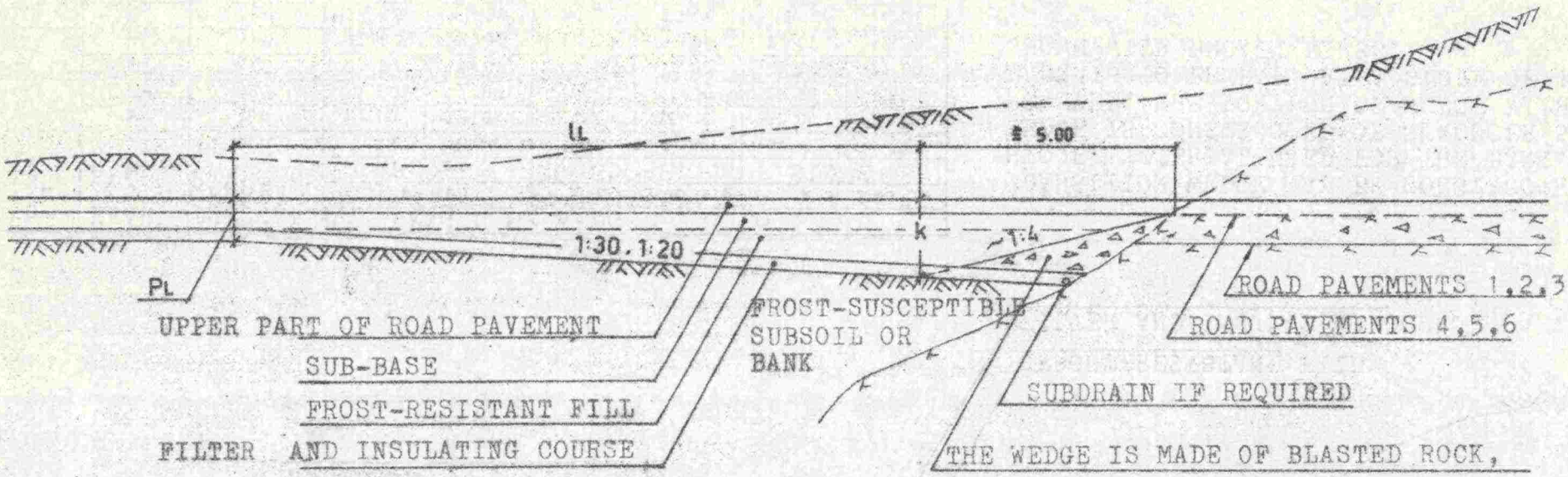
See the general aspects for construction in winter given in Item 1100.

When excavation operations are carried out in winter, topsoil and vegetation should be removed from earth cuttings the material of which is suitable for use in road structures at a time when the ground is unfrozen. During the work, snow and ice shall be removed from the excavation as accurately as possible. The removal of snow shall be arranged in such manner that it will proceed at a rate required by excavation operations. Trampling of snow shall also be avoided.

Frozen lumps removed from the surface and the heading shall be placed in structures specified later on in connection with the construction of embankments. Frozen soil may be stored temporarily, if necessary (e.g. road pavement material).

ROAD PAVEMENT LAYERS
TRANSITION WEDGE

FROST-SUSCEPTIBLE EARTH CUT OR BANK/ROCK CUT

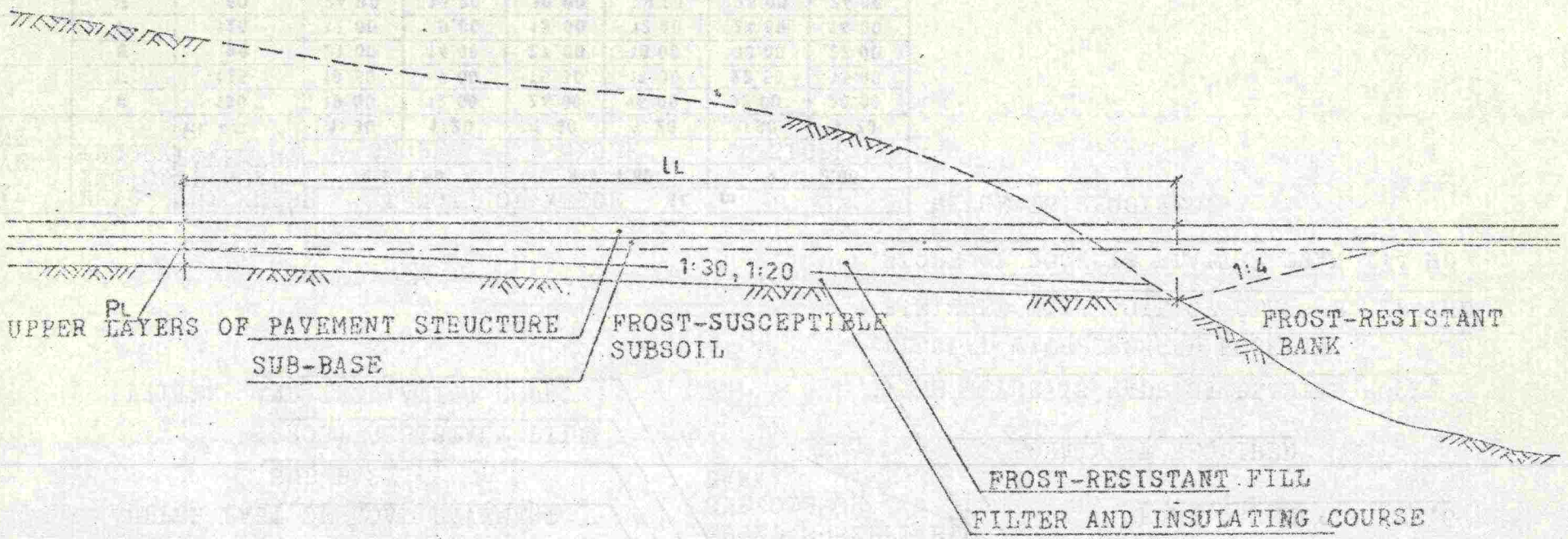


THE WEDGE IS MADE OF BLASTED ROCK, BLINDED WITH CRUSHED ROCK AND FINISHED WITH SOIL OF CLASS B. IF THE SLOPE OF ROCK IS FLATTER THAN 1:4 NO WEDGE IS REQUIRED.

ROAD PAVE-MENT	BEAR-ING CA-TEGORY	THICKNESS OF ROAD PAVEMENT	LENGTH OF WEDGE ll m					
			k = 1.60		k = 1.80		k = 2.00	
			SLOPE		SLOPE		SLOPE	
		Pl cm	1:30	1:20	1:30	1:20	1:30	1:20
1	E	100	18.00	12.00	24.00	16.00	30.00	20.00
	F	125	10.50	7.00	16.50	11.00	22.50	15.00
2	E	90	21.00	14.00	27.00	18.00	33.00	22.00
	F	120	12.00	8.00	18.00	12.00	24.00	16.00
3	E	80	24.00	16.00	30.00	20.00	36.00	24.00
	F	110	15.00	10.00	21.00	14.00	27.00	18.00
4	E	75	25.50	17.00	31.50	21.00	37.50	25.00
	F	100	18.00	12.00	24.00	16.00	30.00	20.00
5	E	65	28.50	19.00	34.50	23.00	40.50	27.00
	F	90	21.00	14.00	27.00	18.00	33.00	22.00
6	E	60	30.00	20.00	36.00	24.00	42.00	28.00
	F	80	24.00	16.00	30.00	20.00	36.00	24.00

ROAD PAVEMENT LAYERS
TRANSITION WEDGE

FROST-SUSCEPTIBLE CUT/FROST-RESISTANT BANK



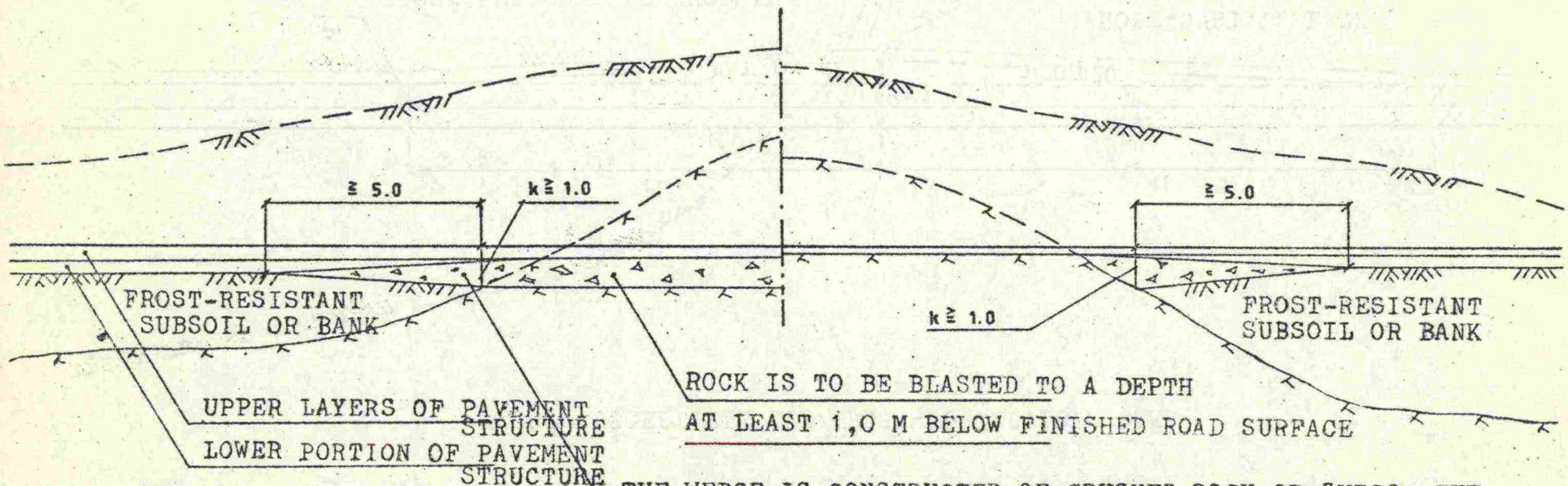
ROAD PAVEMENT	BEARING CATEGORY	THICKNESS OF ROAD PAVEMENT	LENGTH OF WEDGE ll m					
			k = 1.60		k = 1.80		k = 2.00	
			SLOPE		SLOPE		SLOPE	
		Pl cm	1:30	1:20	1:30	1:20	1:30	1:20
1	E	100	10.00	12.00	24.00	16.00	30.00	20.00
	F	125	10.50	7.80	16.50	11.00	22.50	15.00
2	E	80	21.00	14.00	27.00	18.00	33.50	22.00
	F	120	12.00	8.00	18.00	12.00	24.00	16.00
3	E	80	24.00	16.00	30.00	20.00	36.00	24.00
	F	110	15.00	10.00	21.00	14.00	27.00	18.00
4	E	75	25.50	17.00	31.50	21.00	37.50	25.00
	F	100	18.00	12.00	24.00	16.00	30.00	20.00
5	E	65	28.50	19.00	34.50	23.00	40.50	27.00
	F	90	21.00	14.00	27.00	18.00	33.00	22.00
6	E	60	30.00	20.00	36.00	24.00	42.00	28.00
	F	85	22.50	15.00	28.50	19.00	34.50	23.00

TRANSITION WEDGE MAY BE CONSTRUCTED OF THE STONE. MATERIAL USED FOR THE BANK, IF THE WEDGE IS CONSTRUCTED OF STRONGER STONE. HOWEVER, THE PORTION OF WEDGE WITHIN THE BANK IS TO BE LAID AT A SLOPE OF 1:4 AS SHOWN WITH BROKEN LINES.

FROST-RESISTANT EARTH CUT OR BANK/ROCK CUT

ROAD PAVEMENTS 1,2,3

ROAD PAVEMENTS 4,5,6

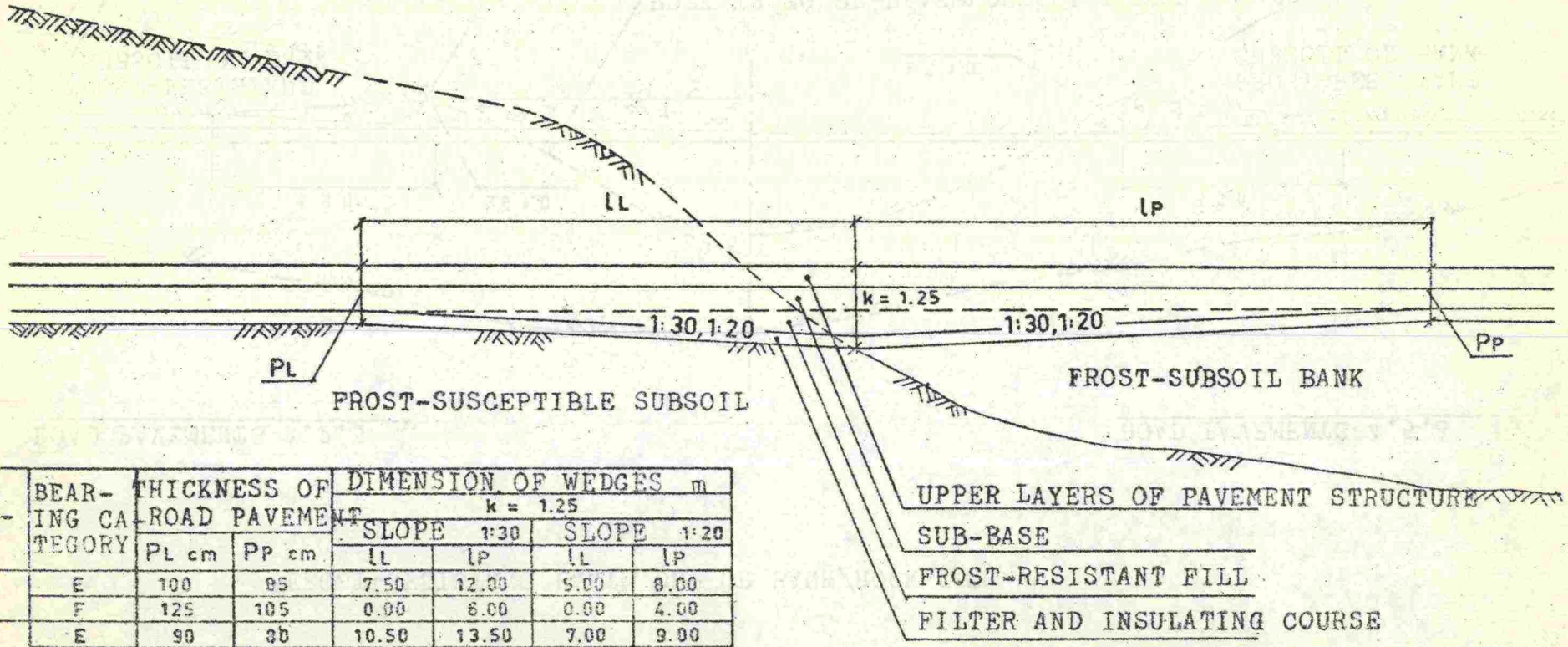


THE WEDGE IS CONSTRUCTED OF CRUSHED ROCK OR CHIPS, THE SURFACE IS BLINDED WITH SMALL CHIPS AND FINISHED WITH SOIL CLASS B.

ROAD PAVEMENT LAYERS

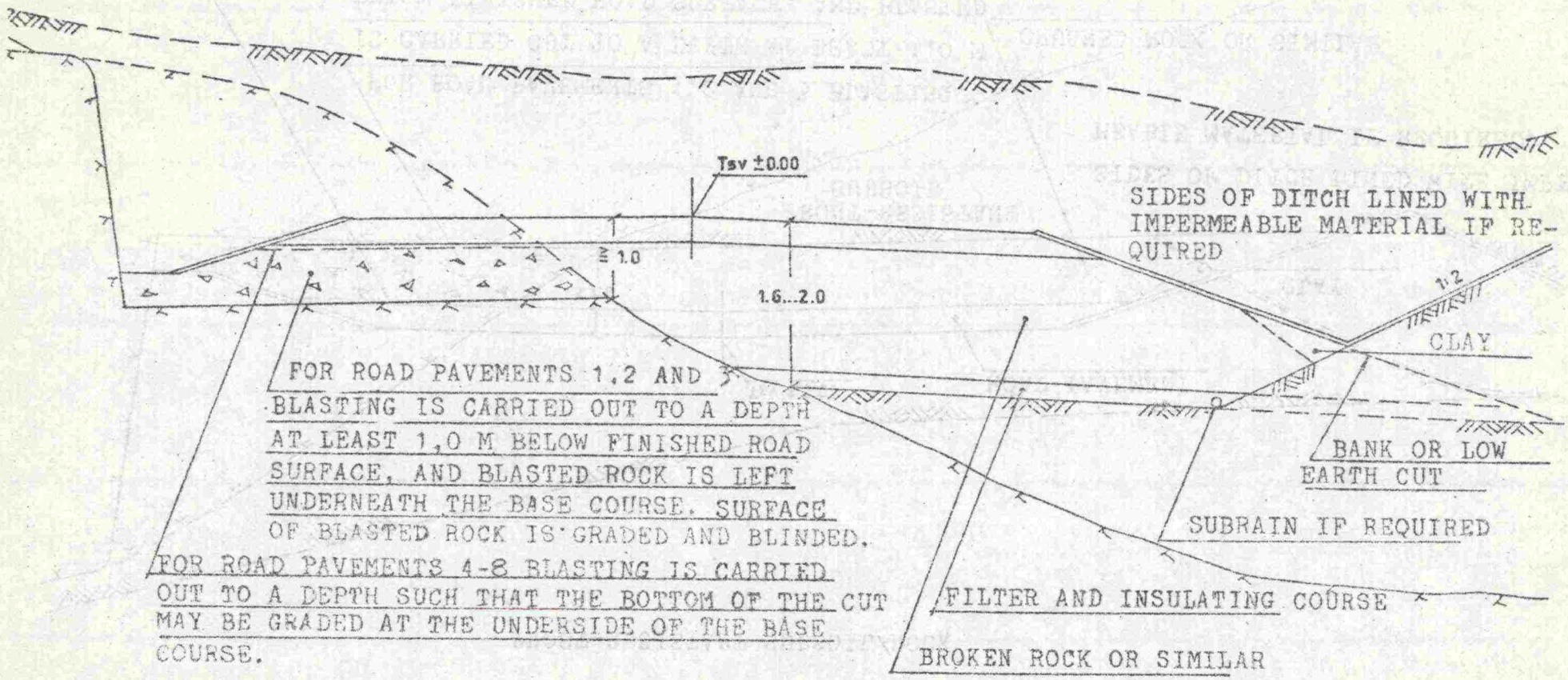
TRANSITION WEDGE

FROST-SUSCEPTIBLE CUT/FROST-SUSCEPTIBLE BANK



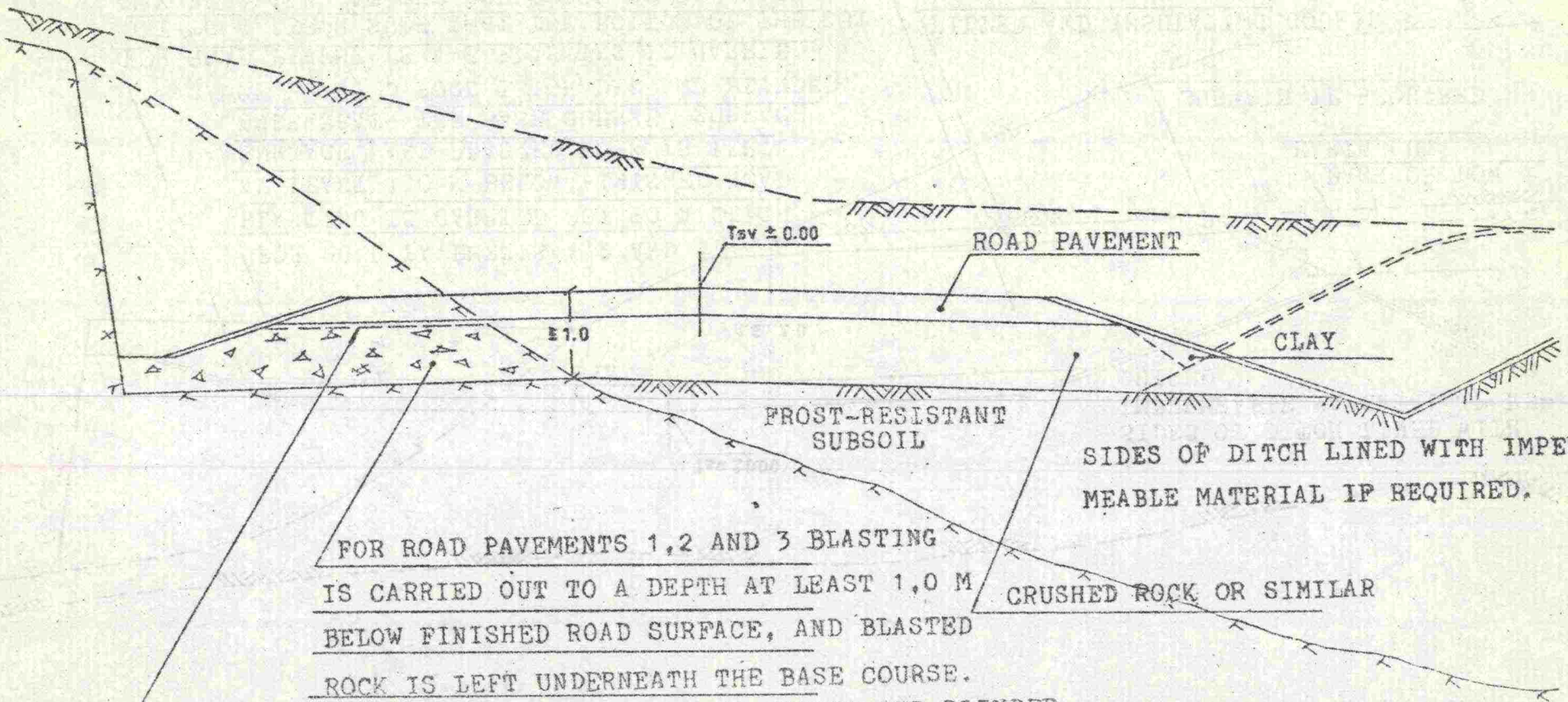
ROAD PAVE-MENT	BEAR-ING CA-TEGORY	THICKNESS OF ROAD PAVEMENT		DIMENSION OF WEDGES m k = 1.25			
				SLOPE 1:30		SLOPE 1:20	
		PL cm	Pp cm	lL	lP	lL	lP
1	E	100	95	7.50	12.00	5.00	8.00
	F	125	105	0.00	6.00	0.00	4.00
2	E	90	80	10.50	13.50	7.00	9.00
	F	120	105	1.50	6.00	1.00	4.00
3	E	80	70	13.50	16.50	9.00	11.00
	F	110	100	4.50	7.50	3.00	5.00
4	E	75	65	15.00	18.00	10.00	12.00
	F	100	90	7.50	10.50	5.00	7.00
5	E	65	55	18.00	21.00	12.00	14.00
	F	90	80	10.50	13.50	7.00	9.00
6	E	60	50	19.50	22.50	13.00	15.00
	F	80	70	13.50	16.50	9.00	11.00

FROST-SUSCEPTIBLE SUBSOIL/ROCK



ROAD PAVEMENT. LAYERS
TRANSITION WEDGE

FROST-RESISTANT SUBSOIL/ROCK



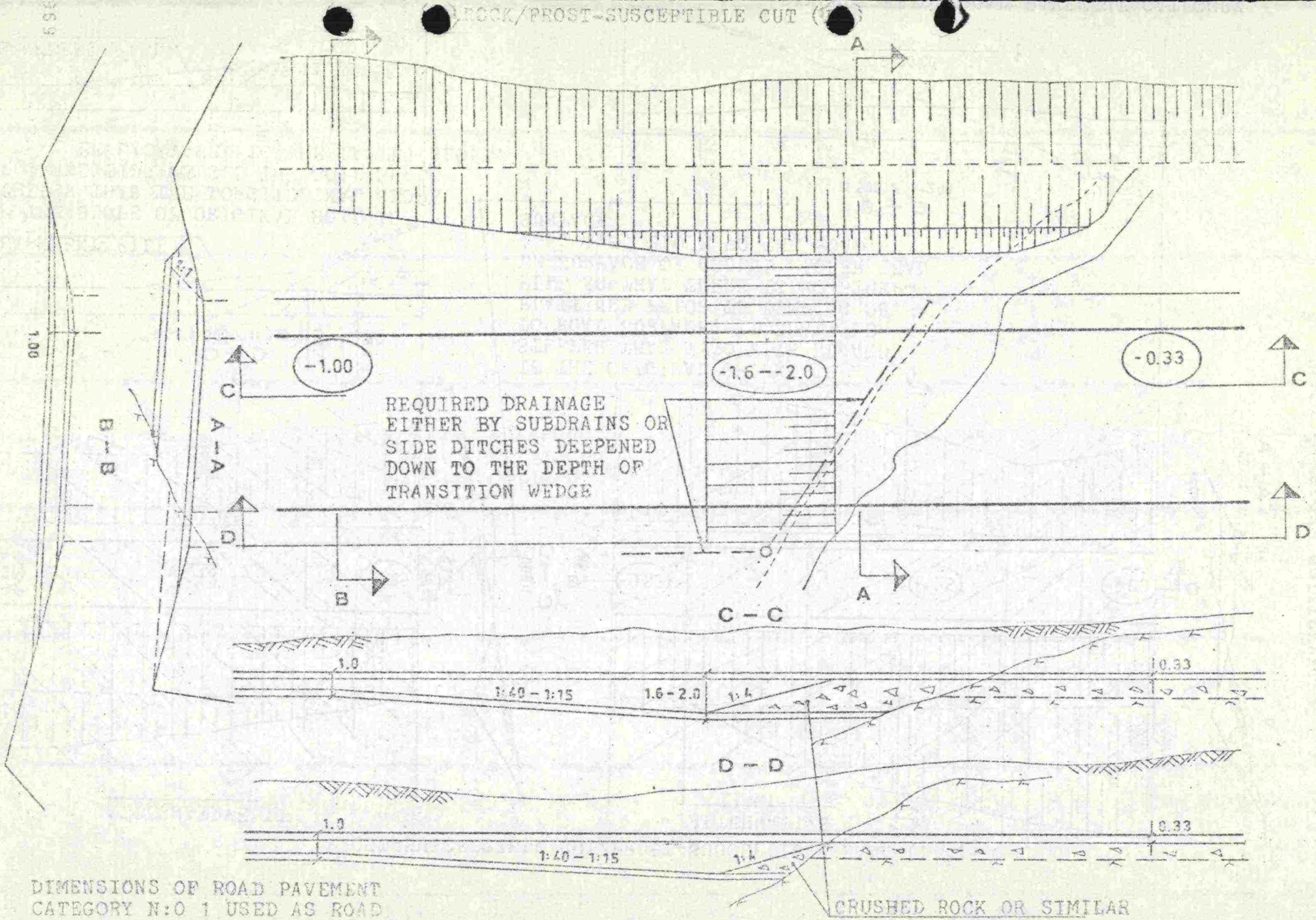
SIDES OF DITCH LINED WITH IMPER-
MEABLE MATERIAL IF REQUIRED.

FOR ROAD PAVEMENTS 1,2 AND 3 BLASTING
IS CARRIED OUT TO A DEPTH AT LEAST 1,0 M
BELOW FINISHED ROAD SURFACE, AND BLASTED
ROCK IS LEFT UNDERNEATH THE BASE COURSE.
SURFACE OF BLASTED ROCK IS GRADED AND BLINDED.

CRUSHED ROCK OR SIMILAR

FOR ROAD PAVEMENTS 4-8 BLASTING IS CARRIED OUT TO A DEPTH
SUCH THAT THE BOTTOM OF THE CUT MAY BE GRADED AT THE UNDER-
SIDE OF THE BASE COURSE.

ROAD PAVEMENT LAYERS
TRANSITION WEDGE

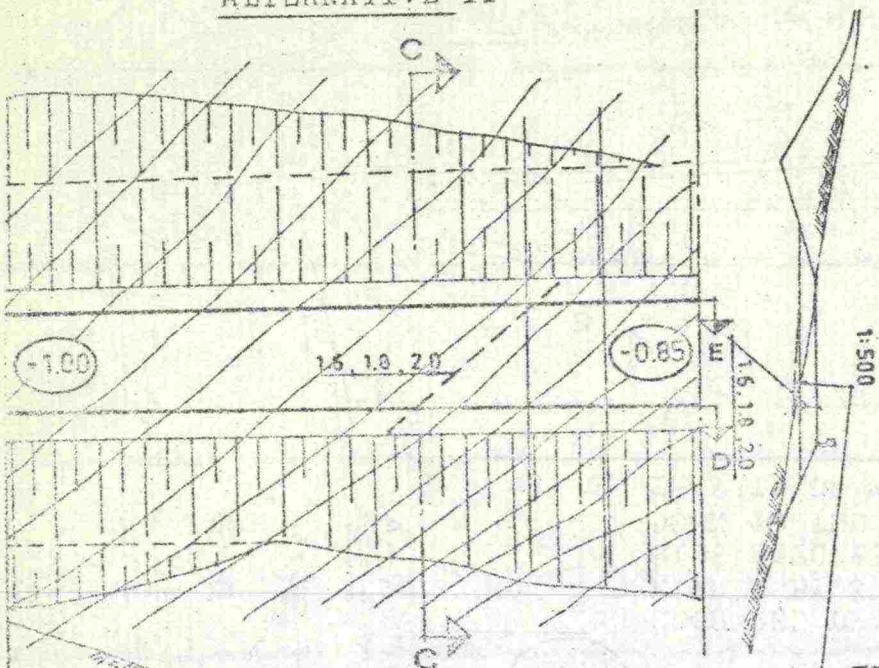


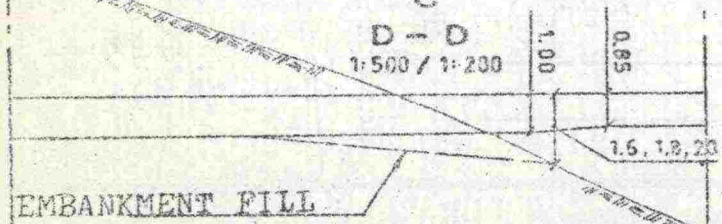
DIMENSIONS OF ROAD PAVEMENT
CATEGORY N:0 1 USED AS ROAD
SCALE 1:200 PAVEMENT DIMENSIONS

ROAD PAVEMENT LAYERS
TRANSITION WEDGE

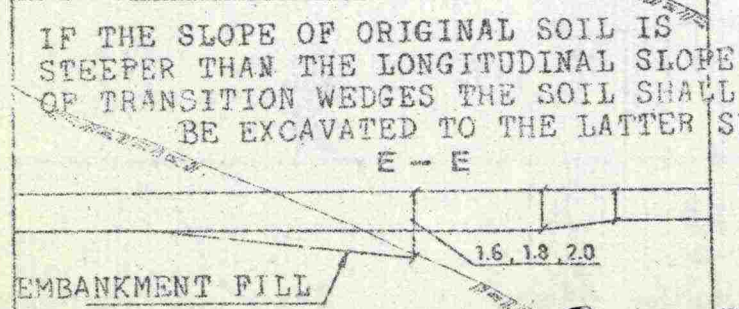
FROST-SUSCEPTIBLE CUT/FROST-SUSCEPTIBLE BANK (E)

ALTERNATIVE II

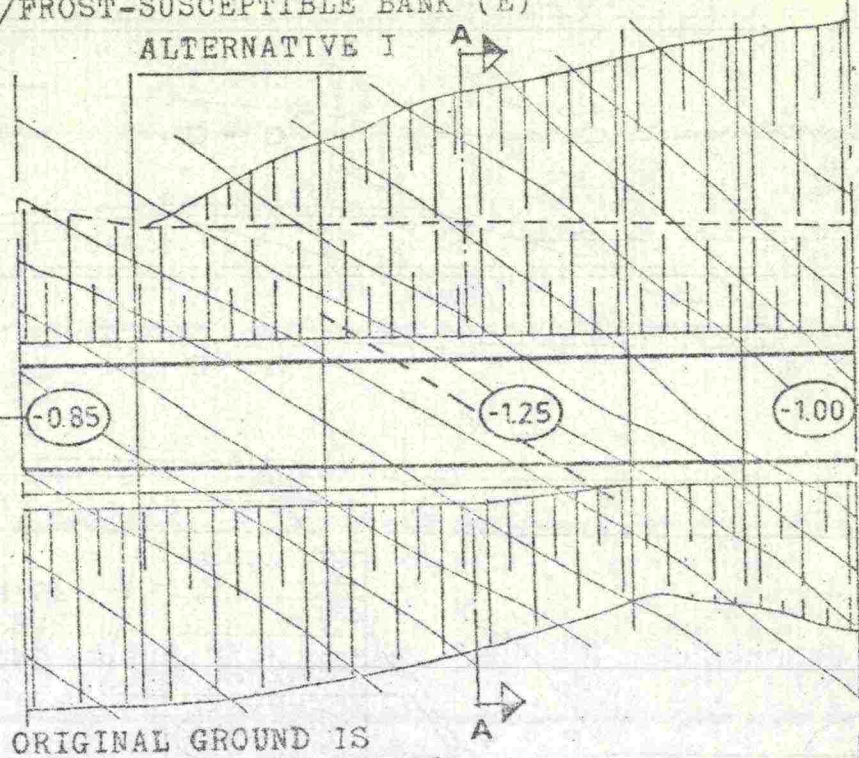


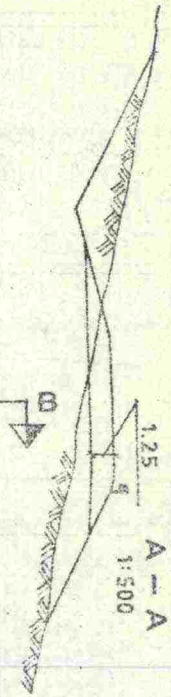


IF THE SLOPE OF ORIGINAL SOIL IS STEEPER THAN THE LONGITUDINAL SLOPE OF TRANSITION WEDGES THE SOIL SHALL BE EXCAVATED TO THE LATTER SLOPES.

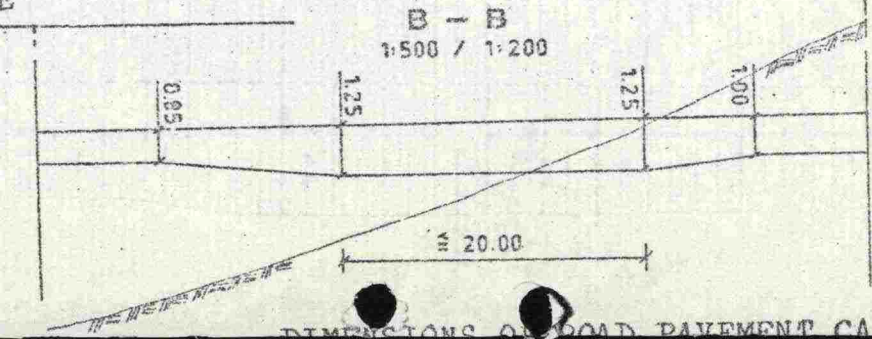


ALTERNATIVE I



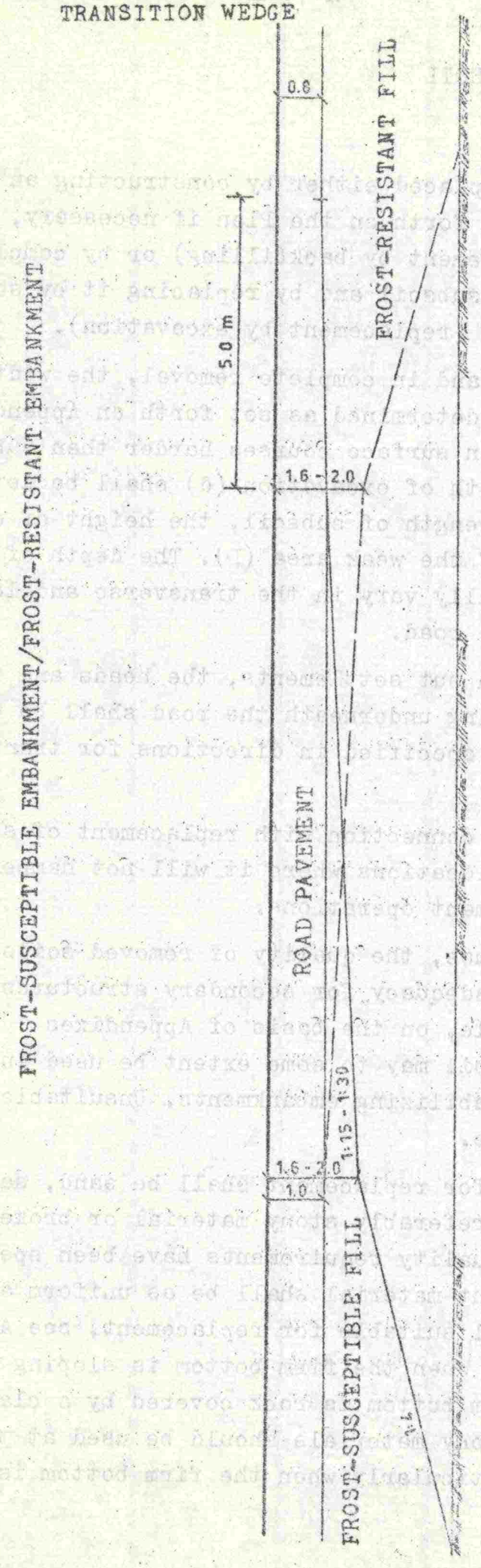


IF THE ORIGINAL GROUND IS STEEPER THAN 1:10 WITH REGARD TO ROAD SURFACE, IT SHALL BE FLATTENED PRIOR TO DUMPING OF FILL SO THAT THERE IS NO STEEPER SURFACE OF GROUND CLOSER THAN 1,6, 1,8, 2,0 M TO THE ROAD SURFACE



DIMENSIONS OF ROAD PAVEMENT CATEGORY

ROAD PAVEMENT LAYERS
TRANSITION WEDGE



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1520 REMOVAL OF WEAK SOIL

General

Soil shall be replaced either by constructing an embankment down to the depth set forth on the Plan if necessary, assisted by blasting (replacement by backfilling) or by complete or partial removal of weak subsoil and by replacing it by soil of a higher bearing capacity (replacement by excavation).

Both in partial and in complete removal, the width of the trench bottom shall be determined as set forth on Appendix 1. In partial removal, when surface courses harder than subsoil shall be removed, the depth of excavation (d) shall be determined on the basis of the strength of subsoil, the height of embankment (H) and the depth of the weak area (D). The depth of excavation shall not generally vary in the transverse and longitudinal direction of the road.

In order to even out settlements, the heads and the ends of trenches remaining underneath the road shall be constructed to a flat slope as specified in directions for transition wedges and in Item 1540.

Soil removed in connection with replacement of soil shall be hauled away to locations where it will not hamper the performance of replacement operations.

Prior to their use, the quality of removed soils shall be examined and their adequacy for secondary structures shall be determined, for example, on the basis of Appendixes 1 and 2 in Item 1540. Removed soil may to some extent be used in embankment slopes or in stabilizing embankments. Unsuitable materials shall be hauled to tip.

Materials used for replacement shall be sand, sandy moraine or some coarser, preferably stony material or broken rock, unless more detailed quality requirements have been specified on the Plan. Replacement material shall be as uniform as possible. As regards material suitable for replacement, see Appendixes 1 and 2 of Item 1540. When the firm bottom is sloping to the sides, or when the firm bottom is rock covered by a clay layer, broken rock or very stony materials should be used at the bottom of the embankment, particularly when the firm bottom is rock. At the

bottom of the replacement area, in particular when an embankment is constructed for replacement of soil, material as rich in stones as possible shall be used.

Should structures with pile foundations be constructed in the replacement area, the replacement material shall be suitable for piling (sand, gravel with small stones $\emptyset \leq 100$ mm).

In spite of stabilizing measures, after-settlements are common in weak areas. In order to make most of settlements occur before the road is surfaced and in order to achieve economic use of material used for any surcharge, the weak areas should be constructed at the initial stage of the work.

Replacement by Embankment Construction

Prior to the start of displacement operations, the initial trench shall generally be made by removing surface soil down to a depth and to an extent set forth on the Plan or indicated during the work. Unless otherwise provided on the Plan, the excavation shall be carried out in conformity with principles set forth on Appendix 1.

The embankment shall be constructed by the end-tipping method as a high embankment (embankment height + surcharge) in such a way that the head of the embankment has a form of a 90° wedge displacing soil to the sides. If the firm bottom lies at a slope, the head of the embankment shall be at an angle of 45° to the centre line of the road in such manner that subsoil will be pushed to the sides from the shallower edge of the weak area towards the deeper edge.

If possible, the embankment should be constructed from one direction. When constructed from two directions, the welding of the heads of the embankment should not be carried out at the deepest spot of the weak area. In that case, the surface soil of the weak area shall be removed from the junction. The work should absolutely be carried out uninterruptedly. Should it be necessary, however, to discontinue the work for a longer period, any subsequent measures to be taken to make settling continue again shall be submitted for approval before the work is started.

Any soil that may be pushed up in front or at the sides of the embankment making filling down to the firm bottom difficult shall be removed, if necessary down to the level shown on the Plan or specified during the work.

During construction and after the completion of the embankment the shape and the depth of the embankment shall be checked by following the consumption of material, by making drillings at the sides or through the embankment. Should it be found that the embankment is not in compliance with the minimum requirements specified on the Plans, blastings at the sides and/or at the bottom, raising of the surcharge height and/or lengthening the time of settlement shall be used in order to obtain the desired results by using methods specified separately for each case.

The embankment shall be surcharged using the method and for a period set forth on the Plans. In order to achieve the breaking state, any moving temporary surcharge at the head of the embankment shall be constructed, depending on the depth of the embankment, over a length of about 10...15 m sufficiently higher than the final surcharge unless otherwise specified on the Plans. Directions given in Item 1550...1560 regarding surcharges shall be followed.

R e p l a c e m e n t b y E x c a v a t i o n

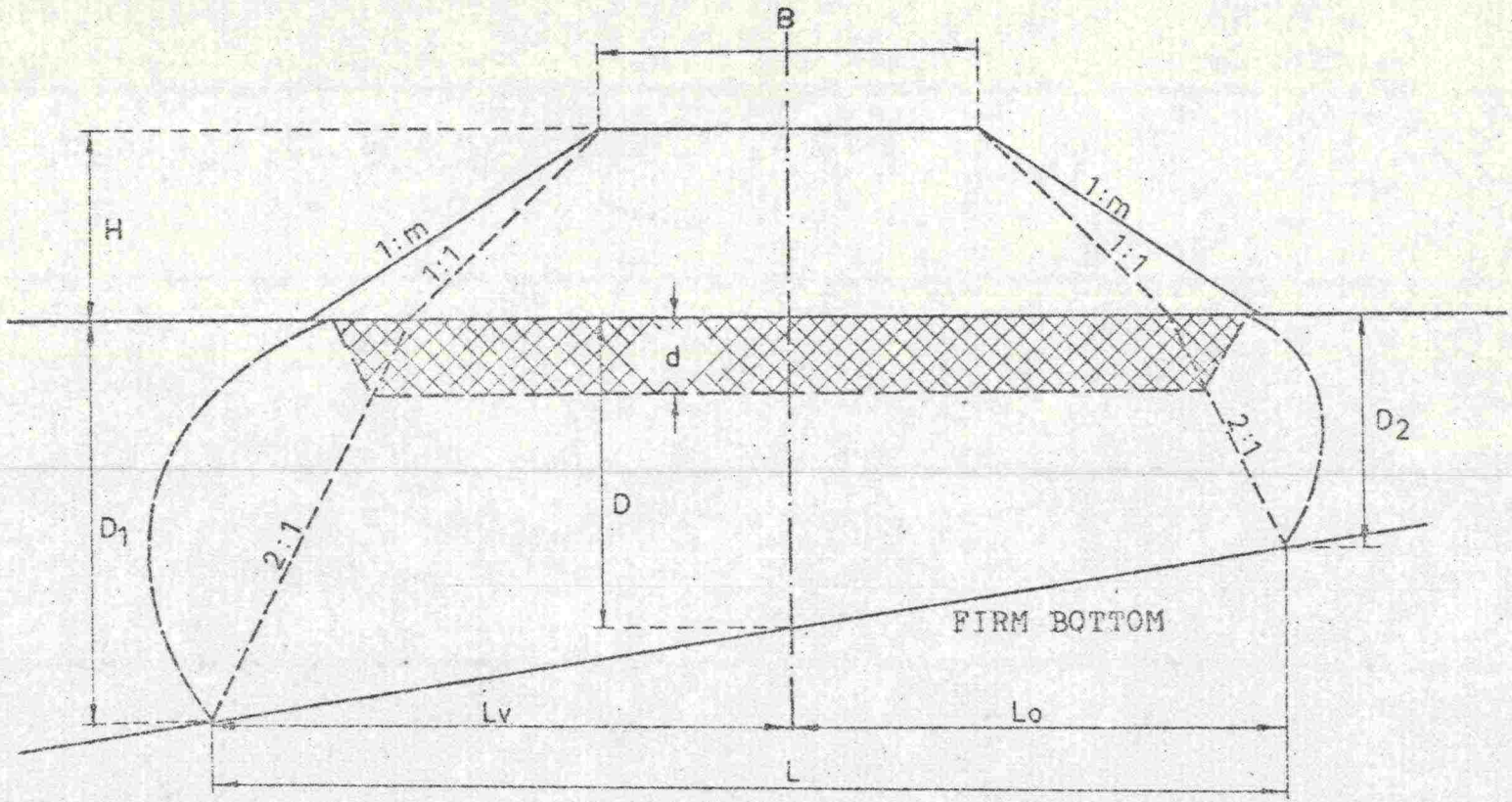
The original soil shall be removed by excavating or dredging to the depth and extent provided on the Plans or specified during the work separately for each case. Unless otherwise provided on the Plan, excavation operations shall be carried out in conformity with principles given in Appendix 1.

The embankment shall be placed immediately in order to decrease the risk of the slopes of the trench slipping. In certain cases filling the trench with water may be an advantageous solution for the prevention of slope failures.

In connection with complete removal, the portion of the embankment above water shall be constructed in layers by following the general directions given in Item 1540. Should there be no risk of the sides of the trench slipping, it may in certain cases be advantageous to remove water from the trench and to construc

the embankment from the bottom of the trench in conformance with the general directions given in Item 1540. In that case, the embankment material needs not be of such a high quality as in embankments under water.

INITIAL TRENCH



WIDTH OF FILL AT FIRM BOTTOM

1540 EMBANKMENTS OF SOIL

General

Bearing and frost-resistant soils in an embankment should be placed in the upper portion of the embankment.

Prior to the start of actual embankment construction, the bases of embankments shall be brought to such a condition that they will not cause any uneven settlement in the road. All ditches, cavities and deep culvert trenches, excluding the backfill, shall be filled with soil from the surrounding area or with similar material in so thin layers and with such compaction that a density as similar to the density of the surrounding area as possible is obtained. Depending on each case, ditches and cavities shall be treated either by cutting the sides above the depth of transition wedge to a slope of 1:10 and below the depth of transition wedge to a slope of 1:40 or by using some other method ensuring that no uneven settlements will occur. If an existing road or a construction road is to lie underneath the embankment, the portion of the existing road lying closer than the depth of transition wedge - 1,6 m, 1,8 m or 2,0 m - to the surface of the new road, shall be excavated and soil materials shall be hauled away or spread in uniform layers under the new road and compacted. An existing road or part thereof below this level shall be shaped in such manner that the interface of the existing road and the embankment of the new road will at no spot have a slope steeper than 1:4.

Filling operations shall be carried out so that any future irregularities and consolidations are as small as possible. The embankment shall therefore be constructed in uniform layers.

The interface of a frost-resistant and a frost-susceptible fill shall be made so that the slope of the surface, in relation to the principal longitudinal profile, conforms to the directions given for the area of transition wedge (1,6m, 1,8 m or 2,0 m) in Appendix 9 of Item 1510. In other cases (frost-susceptibility the same or the surface deeper than 1,6 m, 1,8 m or 2,0 m), the slope of the interface shall be 1:4 or flatter.

Each layer shall conform to the specified density and other specifications before the next layer can be laid.

E m b a n k m e n t i n E a r t h

Material

All compactible mineral soils with the exception of clay are suitable for embankment materials (see Appendixes 1 and 2). If possible, the work shall be scheduled and arranged so that suitable material has not to be rejected because of weather and ground water conditions.

Dry crust clay may be used in embankments with special permission by using special methods. As a rule, clay may be used only for grading of similar subsoil or in surcharges. Organic soils may generally be used only for grading of similar subsoil. The soil shall not contain stones or boulders with a diameter larger than 2/3 of the thickness of a layer to be compacted at one time. Lower-class materials (e.g. clay) may be used outside the imaginary slope of 1:1.5 drawn from the bend of the surface of the subgrade and the slope, but account shall be taken of any widening of the road in the future. The outflow of water from the embankment shall be ensured. If frost-resistant material coarser than insulating sand is used as embankment fill on subsoils of Category E or F, a filter course shall be laid below an embankment lower than 1,5 m or, if necessary, even below higher embankments in order to prevent the so-called pumping effect. In underwater embankments or in displacement of soil by filling, the fill shall be as coarse as possible. The finest material that may be used in exceptional cases is sand moraine. A special permission shall be obtained for the use of finer materials. In underwater embankments, the use of frost-susceptible materials shall be avoided within an area between 0.5 m below the water level and 0.5 m above the high water level. The material used within this area shall be insulating sand or coarser and if necessary, filter material shall be used in order to prevent different soil layers from mixing.

Construction in Layers

Embankments less than 6 m in height, measured from the principal longitudinal profile, shall be constructed in layers, in cases when Road Pavement Category 1 is used. Corresponding heights for other Road Pavement Categories are as follows:

Road Pavement Category	2 and 3	height less than	6,0 m
	4	- " -	5,0 m
	5	- " -	4,5 m
	6	- " -	4,0 m
	7 and 8	- " -	- m

The construction shall generally be in layers approximately parallel with the principal longitudinal profile. Each layer shall be spread over the full width account being taken on the widening of the embankment during construction. The thickness of a layer to be placed and compacted at one time shall be such that the layer may be sufficiently compacted by available compacting equipment. Should the embankment, however, be constructed on such subsoil as will not carry the load of machines to be used, the first layer may be made thicker in such manner that it will carry the load of machines. In that case the thickness of the layer shall not exceed 1,0 m. Should it be found during the work that the subsoil is not able to carry the vibration caused by compacting equipment, the first layer shall not be compacted. Prior to the continuation of the work, special directions shall be requested.

When an embankment is built over water, construction in layers shall be started as soon as the height of the embankment reaches the level above water such that it will carry the weight of machines.

When wet fine sand or silt is used as fill material, a layer at least 30 cm in thickness shall be laid of materials of Class C or D per each embankment section about 0,7...1,4 m in thickness (sandwich construction) in order to drain off water from the embankment. Under adverse conditions only one layer of fill material (about 70 cm, depending on compacting equipment) should be laid between the layers conducting water. In good conditions two layers may be compacted before the layer conducting water is laid. Special care shall be taken to ensure that the layer con-

ducting water is not damaged. In the sandwich construction and when the fill is frost-susceptible, the surface of each layer shall be graded and shaped to a sufficient crossfall (1:10... 1:20) so that water may be drained off as quickly as possible from the embankment. The crossfall of the surface of each layer shall be equal or larger than the crossfall of the surface of the embankment specified on the Plan.

Construction by End Tipping

Embankments in soil more than 6 m in height (Road Pavement Category 1) may be constructed by end-tipping for the portion at a depth larger than 6 m from the principal longitudinal profile (corresponding height limits for other Road Pavement Categories are 6,0, 6,0, 5,0, 4,5, 4,0 and 0 m). Care shall however be taken in end-tipping method to ensure that fill material loads are dumped on the top of the embankment and pushed over by means of bulldozers or similar plant in a shape of a wegde of 1:4 or flatter. In this case the embankment is compacted to some extent also by the machine which will reduce subsequent consolidation normally occurring later on high embankments.

Should the road pavement be constructed later, however, not earlier than one year after the completion of the embankment, the method of construction of a high embankment may be altered so that the portion lying lower than 3 m form the principal longitudinal profile is constructed by end-tipping so that material is pushed down by means of bulldozers or similar plant in a shape of a wedge of about 1:4 and the portion above is laid in layers. Precautions shall then be taken to carry out grading and compacting of the surface before the road pavement is constructed. This method shall not be used in side-sloping terrain, if the embankment would be evidently unhomogeneous.

On roads with Road Pavement Categories 7 and 8, the end-tipping method may be used over the entire embankment by carrying out the after-compaction of the surface of the subgrade.

If the bearing capacity of the embankment base is sufficient, but the surface is so soft - e.g. muddy clay or silt - that constructing an embankment proves impossible, the surface layer shall be prepared in conformance with instructions given in Item 1220,

when applicable. The construction of the embankment shall then be continued by the normal method.

C o m p a c t i o n

Each layer shall be compacted into the required density by using appropriate compacting equipment. The tracks of hauling equipment shall be spread over the full width of the embankment in order to obtain adequate pre-compaction. The material shall be spread and rolled as soon as the load has been dumped, since the fill then generally has a moisture content suitable for compaction. In addition to hauling and spreading equipment, actual compacting equipment such as vibrating, smooth-wheeled and pneumatic tyred rollers as well as vibratory plates and other compacting plant shall be used. A general principle to be followed in the use of compacting equipment is that vibratory plant should be used in compacting friction soils. Pneumatic tyred and smooth-wheeled rollers may be used both in friction and in cohesive soils.

The required density will best be obtained when the moisture content of the material is near the optimum. If necessary, water may be added to the layer to attain a suitable moisture content. Water shall be added in uniform quantities over the area to be compacted. Should the layer to be compacted have too large a moisture content, dry fill material may be added into the layer or the evaporation may be accelerated mechanically, e.g. by harrowing.

When compacting cohesive soils, attention shall be attached to the fact that evaporation of excess water from these soil types is very slow. If the difference between the original moisture content and the optimum is larger than 3 % points, the required 95 % density will not generally be obtained. If the density requirement is 90 %, the difference shall not exceed 6 % points. Should the moisture content of a cohesive or an intermediate soil type be larger than specified above, or if rain may moisten the embankment, it must be considered whether it is possible to carry out the work under prevailing conditions.

The surface moisture of the soil may be decreased by means of i.e. lime stabilization or in warm weather, a period of few days

may make it possible to compact the material into the required density.

In order to obtain the required density, the optimum moisture content, the maximum dry density and the number of roller passes required should be determined by advance tests. The moisture contents and dry densities given in Table 1 below may be used as rough design values for different materials.

Table No. 1

Soil Type	Optimum Moisture Content %	Maximum Dry Density g/cm³
gravel, gravel moraine	5...10	2,0...2,2
sand, coarse silt	5...15	1,7...2,2
silt, fine silt	15...25	1,6...1,8
clay	20...30	1,4...1,7
sandy, silty moraine	5...10	2,0...2,3

It has been shown by experience that if the moisture content is near the optimum, the required density will be obtained by using layer thicknesses and roller passes given in Table 2 below. The Table is given only as an instruction.

Table No. 2

Compacting Equipment	Weight tons	Suitable layer thickness cm	Number of Roller Passes	Remarks
Towed vibratory rollers	2...3,5	30...50	3...6	Unsuitable for ssilts and clays
Towed vibratory rollers	4...8	50...70	3...6	Unsuitable for clays and silts and generally for winter use
Self-propelled vibratory rollers	2,5	40	4...5	
Self-propelled vibratory rollers	3...6	40...50	4...5	
Pneumatic tyred rollers:				
light	<10	15...20	6...12	Effective depth depends on contact pressure and soil type etc.
heavy	>10	20...50	6...12	
Smooth-wheeled rollers	10	20	5...8	Generally unsuitable for winter use and for wet cohesive soils
Sheepsfoot rollers	5...8	20	6...12	Generally suitable only for finegrained soils
Vibratory plates:				
light	0,1..0,5	30...40	3...6	Generally suitable only for friction soils
medium	0,5..1,5	40...50	3...5	
heavy	>1,5	50...70	3...5	

Excessive rolling shall be avoided since it will frequently result in resoftening of the soil.

In conjunction with the compaction of each layer, the surface shall be shaped and graded in such manner that there will be no depressions ponding water on the surface.

Density Requirements

The degree of density means a percentage indicating the relation between the dry density determined in field tests and the maximum dry density determined in the laboratory by means of the improved Proctor method.

The average of the density values of each layer in the embankment fill or the bottom of the cutting shall be not less than specified in Table No. 3 below. An individual sample shall not deviate from the specified density value by more than 5 % points downwards. Should the deviation be larger, the density shall be checked by new tests before additional compaction of the structure is required.

Table No. 3

Minimum average density required

Road Pavement Category	Depth from Principal Longitudinal Profile	Bearing Category B,C and D	Bearing Category E and silt
1, 2 and 3	2,0...6,0	90	87
	< 2,0	95	92
4	1,5...5,0	90	87
	< 1,5	95	92
5, 6	on the surface of the subgrade	95	92

If the density is controlled by other methods, the relation between the results of these methods and the improved Proctor Method shall be determined.

If crushed stone 0...200 mm is used in the sub-base in a stone embankment and if this layer is covered with the lower portion of the base course made of crushed stone 0...65 mm, it is not necessary to compact the interface. A plate loading test is neither necessary in that case.

Embankments Near Special Structures

Alongside and in the vicinity of special structures such as bridges, culverts, ducts and other engineering structures, the embankment shall be constructed and compacted by applying the

specifications for the construction of road embankments. Great care shall be taken in the work to ensure that the structures are not damaged.

When fill material is placed on both sides of structures, the work shall be carried out so that filling and compacting are performed approximately simultaneously on both sides. Fill material shall not be placed against concrete structures before the structures have attained 80 % of the required 28 days' strength unless otherwise specified.

The density of embankments near structures shall conform to the density requirements specified for embankments unless otherwise specified.

Unless otherwise provided on the Plan, in the area indicated on Appendix No. 3, the embankment near bridges and similar permanent structures shall be constructed of frost-resistant material to a 95 % density.

Special care shall be taken to ensure by excavating, rounding-off, compacting and by other operations that the steep sides of the excavation will not cause irregularities in the road.

Filling of Bridges and Bank Ends

Filling with Gravel

Unless otherwise provided on the Plan, stony gravel shall be used as fill material behind abutments, in bank ends and slopes within an area starting from the foundation slab and ending at the ends of wing walls. Any damage to structures during backfilling shall be prevented.

Filling with Broken Rock

In cases when concrete surfaces are not treated with bitumen, the area behind may be filled with broken rock. The maximum size of boulders lying against the non-insulated concrete surface may be 30 cm. In backfilling against concrete surfaces, special care shall be taken. The broken rock material shall be hauled and graded in layers, the maximum thickness of the layer being 1,0 m. Should there be structures susceptible to damage in the backfill area, e.g. plastic pipes, gravel fill extending not less than

60 cm above the top of the structure concerned shall be used. Compacting shall be in conformance with the above special directions and it shall be extended also to bank ends and slopes, where allowance shall also be made for any settlements. Backfilling in frame, prefabricated and arch bridges shall be simultaneous on both sides. In the area indicated on Appendix No. 3, frost-resistant fill material shall be used and the density of 95 % shall be obtained.

Sewerage

Measures shall be taken to prevent water from collecting behind the base walls.

Transition from Bank Ends to Normal Road Cross Section

If the bridge embankment is high and calls for guardrails in accordance with the Standard Specifications of the National Board of Public Roads and Waterways, the normal cross-section of the road shall extend to the end of the bridge, from which the surface of the bank end shall start to bend changing gradually, if necessary (cf. normal cross-section, type b).

When the embankment is low and calls for a flat road slope (normal rock cross-section, type a), the transition from the bank end to the normal slope shall be gentle.

In that case, directions given in Road Standard Specifications concerning the arrangement of the transition of the cross-section type and the length of guardrails shall be followed, when applicable.

B a c k f i l l i n g i n R e p l a c e m e n t o f S o i l

Backfilling

See Item 1520.

Displacement by Blasting

Blasting shall be used in replacement of soil, if the settlement of fill materials to the level and form specified on the Plan cannot be achieved. Depending on conditions, blasting may be

carried out under, in front of or at the sides of the embankment.

In winter conditions, special attention shall be given in blasting operations to the risks, since the explosion wave in frozen ground travels a long way.

Blasting in Front of Embankment

When blasting in front of the embankment, charges shall be pushed into the weak soil by using pipes or boreholes at a spacing of 2...4 m over the full width of the embankment. A section of about 10...30 m shall be exploded at one time, the charges being exploded simultaneously. The distance of the spheres of explosion from the ground level or from the bottom of the trench shall generally be two-thirds or three-quarters of the depth of the required fill. The quantity of explosive - 45 % dynamite - shall be about 50 g per one cubic meter of earth to be displaced. Fill materials shall be dumped into the area as soon as possible after blasting and at least within one week, so that the soil has no time to regain its strength. Blasting shall be as specified on Appendix No. 4.

The embankment shall be constructed in conformance with Item 1520.

Blasting at Sides of Embankment

Blasting at sides of the embankment is often required in order to facilitate the settlement and widening of the sides of the embankment into a shape specified on the Plans. The necessity of blasting shall be examined by check drillings. Blasting at the sides of the embankment shall be carried out as soon as possible after dumping of the embankment fill.

Charges shall be placed underneath the edges of the embankment, normally in one row at a spacing of about 3...5 m. The size of charges in relation to the quantity of earth to be displaced shall be larger than in blasting in front of embankment (Appendix No. 5). Blasting shall be simultaneous over the largest possible length.

Blasting under Embankment

Blasting underneath the embankment is best suited for narrow embankments and for cases when an old road embankment shall be settled down to a sufficiently firm bottom.

The quantity of dynamite, the minimum height of fill, the diameter of the charging funnel and the distance of the lower end of the funnel (L) from the surface of the fill embankment, that is, the charging depth, shall be determined by using nomograms in Appendixes 7 and 8. A row of circles tangential to the ground surface, the firm bottom and one another shall be drawn in the longitudinal section of the road (Appendix No. 6). The centres of the circles (spheres) obtained are the centers of spheres of explosion. The radius of each sphere shall be measured. By using values obtained, the following data can be read from the nomogram (Appendix No. 7) for the charge concerned:

- diameter of explosion spheres d (m)
- required quantity of explosive (kg)
- void created in blasting (m^3)
- suitable size of charging funnel ø (")
- required minimum distance of the lower end of the funnel from the surface of the fill embankment L (m)

The distance of the centre of the sphere of explosion from the lower end of the funnel - a (m) - is obtained from Appendix No.

The minimum height of the fill embankment from the ground surface is denoted by H. Then

$$H = L - d/2 - a$$

Prior to dumping of fill material, pipes closed at the lower end required for blasting shall be placed into the ground in locations and at depths calculated accurately in advance, or the pipe shall be pushed through the embankment after dumping of fill materials. If the embankment cannot be easily penetrated, the pipes may be driven under the future or the old embankment obliquely from the sides. Fill material shall be dumped in such manner that no damage is caused to charging funnels and that the embankment is not damaged by detrimental slips before blasting.

After placing of fill material, all charges shall be exploded simultaneously. Dynamite shall be used as explosive material and

electric detonation shall be used in blasting. All detonators shall explode simultaneously.

Fill material shall be dumped in conformance with directions specified in Item 1520 herein. After blasting, stony embankment material shall at once be dumped over the area in such quantities as are required for achieving slower subsequent settlement. A surcharge at least 1 m in thickness shall therefore be kept at the place. The surcharge may be removed as set forth on the Plan. If necessary, subsoil heaving up from the sides and obstructing backfilling operations shall be excavated.

Should the embankment be so wide that the results of blasting can be doubted, combined blasting at the sides and underneath the embankment may be considered.

Treatment of Surface of Subgrade

In addition to the above specifications for the treatment of the surface of cutting and embankments, the following facts shall be taken into account.

Earth Embankment and Earth Cutting

The upper surface of the subgrade shall be graded with the material of the upper portion of the subgrade.

In earth embankments and cuttings, the surface of the subgrade shall be graded and brought to a form set forth on the Plans and compacted as specified. There shall be no depressions ponding water on the surface. The largest permissible average deviation in the level of the surface of the subgrade downwards is -5 cm and upwards +0 cm. The largest permissible individual deviation is -10 cm and +0 cm, respectively.

If the surface is so wet that it is not possible to carry out compaction, any pockets of water shall first be drained, after which the surface shall be graded in order to facilitate drainage. Traffic shall not then be allowed over the formation before the surface has dried sufficiently and compaction has been carried out. If the soil is fine-grained and particularly, if construction traffic uses the surface, it may be practical to

construct a plank grillage or to stabilize the surface e.g. with lime, cement or on lower-class roads, with friction soil as specified in Item 1220. Material that has thus been spread on the formation may not in general be counted as part of the road pavement unless it can be shown that the material is suitable for the road pavement and that it has not become mixed with the underlying soil or spilled material owing to the action of construction traffic. In certain cases it may be necessary to lay a special road for construction traffic.

Completed and drained surfaces may be protected from becoming we by means of spraying bitumen binder, by blinding with sand or by covering the surface with uniformly graded stone chips. The surface may also be covered with a plastic sheeting in which case traffic shall not be allowed on it.

S t a b i l i z i n g E m b a n k m e n t s

Stabilizing embankments shall be constructed in accordance with dimensions given on the Plan or as directed during the work in order to prevent slips of the road embankment and the slopes (Appendix No. 9, Fig.1). Stabilizing embankments shall be constructed of mineral soil types. The dry crust of the subsoil shall not be damaged during construction.

The surface of the stabilizing embankment shall be graded and shaped in such manner that no ponding of water will occur. Bends of slopes shall be rounded off in the way specified separately for road embankments. Slopes shall be soiled as the slopes of em bankments unless otherwise specified.

Unless otherwise specified on the Plan, the difference in height of the road embankment and the stabilizing embankment shall be at least equal to the difference in height of the final principal longitudinal profile and the stabilizing embankment at all construction stages.

If advantageous from the point of view of work organization, material for stabilizing embankment may be dumped before the material for the main embankment. At this stage, the height of the stabilizing embankment shall not, however, be larger than the difference in height of the final embankment and the stabilizing embankment (H') unless otherwise provided on the Plan.

The head of the embankment shall be kept at a flat slope or it shall be stepped in accordance with the dimensions of the stabilizing embankment. By this means slips forward during the work may be prevented. Should the road embankment be constructed of heavier or lighter material than the stabilizing embankment, the dimension of the latter shall be correspondingly changed during the work unless account has been taken of this on the Plan. There is no need to compact the stabilizing embankment.

Prior to the construction of the embankment checks shall be made to find out that there are not such ditches, trenches and other structures in the area that have not been taken into account in the Plan and that may cause slips or uneven settlements in the road. No trenches or structures that may decrease the stability of the road shall be made within the road area without permission. Even actual drainage work shall be scheduled with reference to prevailing conditions.

It shall be borne in mind that the dimensions of the stabilizing embankment set forth on the Plan are generally minimum dimensions. If stabilizing embankment areas are to be used as tips for lower-class material, the size of the stabilizing embankment may be increased. This shall, however, always be agreed with the planner separately in each case.

C o n s t r u c t i o n i n W i n t e r

In construction of embankments during winter, snow and ice shall be carefully removed from below the embankment and from between the dumped layers. The embankment fill shall not contain snow, ice or frozen soil lumps. In compaction, special care shall be taken to ensure that compacting is carried out as soon as possible after spreading, when the soil is not yet frozen and when its moisture content is sufficient. Only one layer about 70 cm in thickness may be constructed on a compacted **but** frozen layer.

After-compaction shall be carried out when the ground is not frozen by using heavy compacting equipment. After this the density shall be checked.

A road pavement should not generally be laid on the embankment during the same winter, with an exception naturally of embank-

ments on which a road pavement has to be constructed owing to traffic arrangements or on which any settlements are negligible from the point of view of their use.

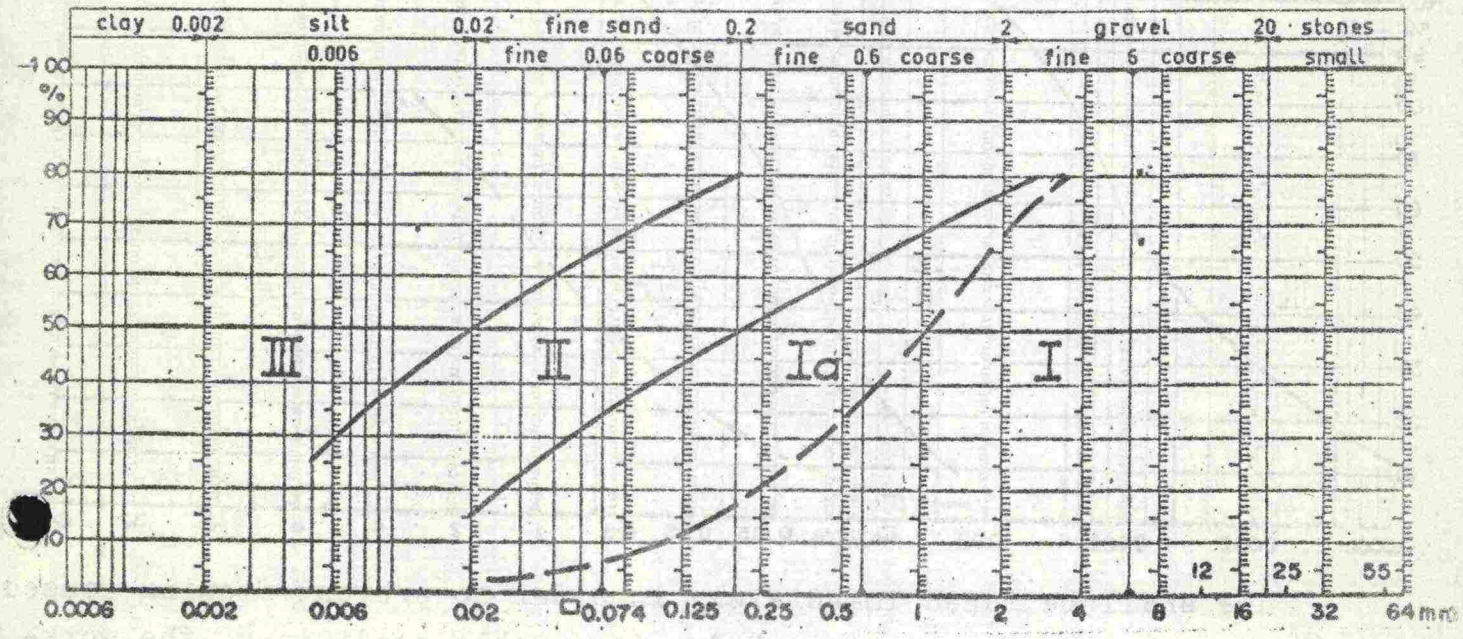
An embankment over water may be constructed in winter. Frozen soils should, however, be placed at the edges of the embankment.

Use of Moraines As
Embankment Fill

I: There are generally no difficulties in the construction and compaction of embankments. The soils of this category are suitable for filling in replacement of soil and in embankments over water.

Ia: Should the fines content of sandy and gravel moraine be large, the moisture content above the optimum may sometimes cause difficulties in the construction work. The coarsest of the soils of this category are suitable for embankment fill also in replacement of soil and in embankments over water.

II: Even a small excessive moisture above the optimum ($\geq$ 2 %) will generally cause difficulties in construction. Large excessive quantities of water (above the liquid limit) may make the soil as such inadequate for embankment fill. In general, the structure shall be faced immediately in



order to prevent flowing caused by surface water erosion. The workability of soils of this category may, under favourable conditions, be improved by lime stabilization.

III: Soils of this category can generally be used as embankment fill under very favourable conditions. These soils are suitable for material in the sandwich construction below the frost line and in stabilizing embankments. In general, the structure shall be faced immediately in order to prevent flowing caused by surface water erosion. Under favourable conditions, the workability of soils of this category may be improved by lime stabilization.

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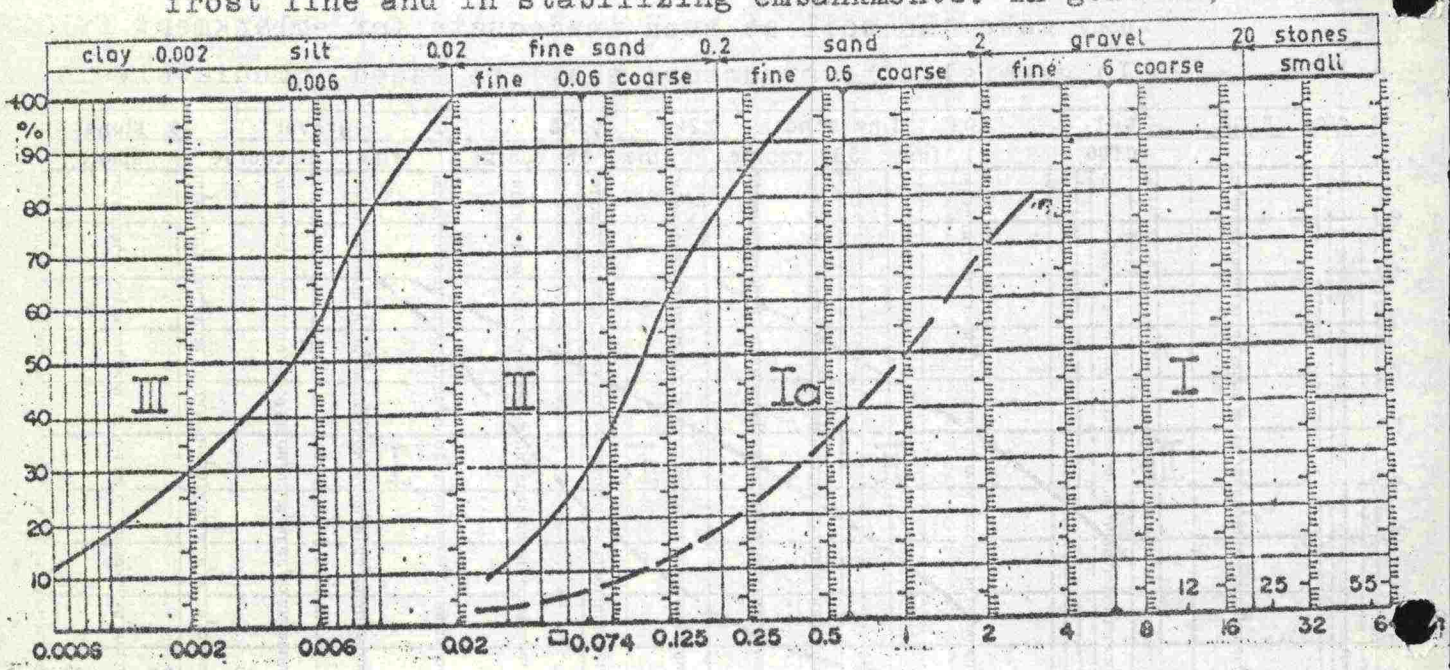
Use of Poorly Graded Soils As Embankment Fill

I: There are generally no difficulties in the construction and compaction of embankments. The soils of this category are suitable for filling in replacement of soil and in embankments over water.

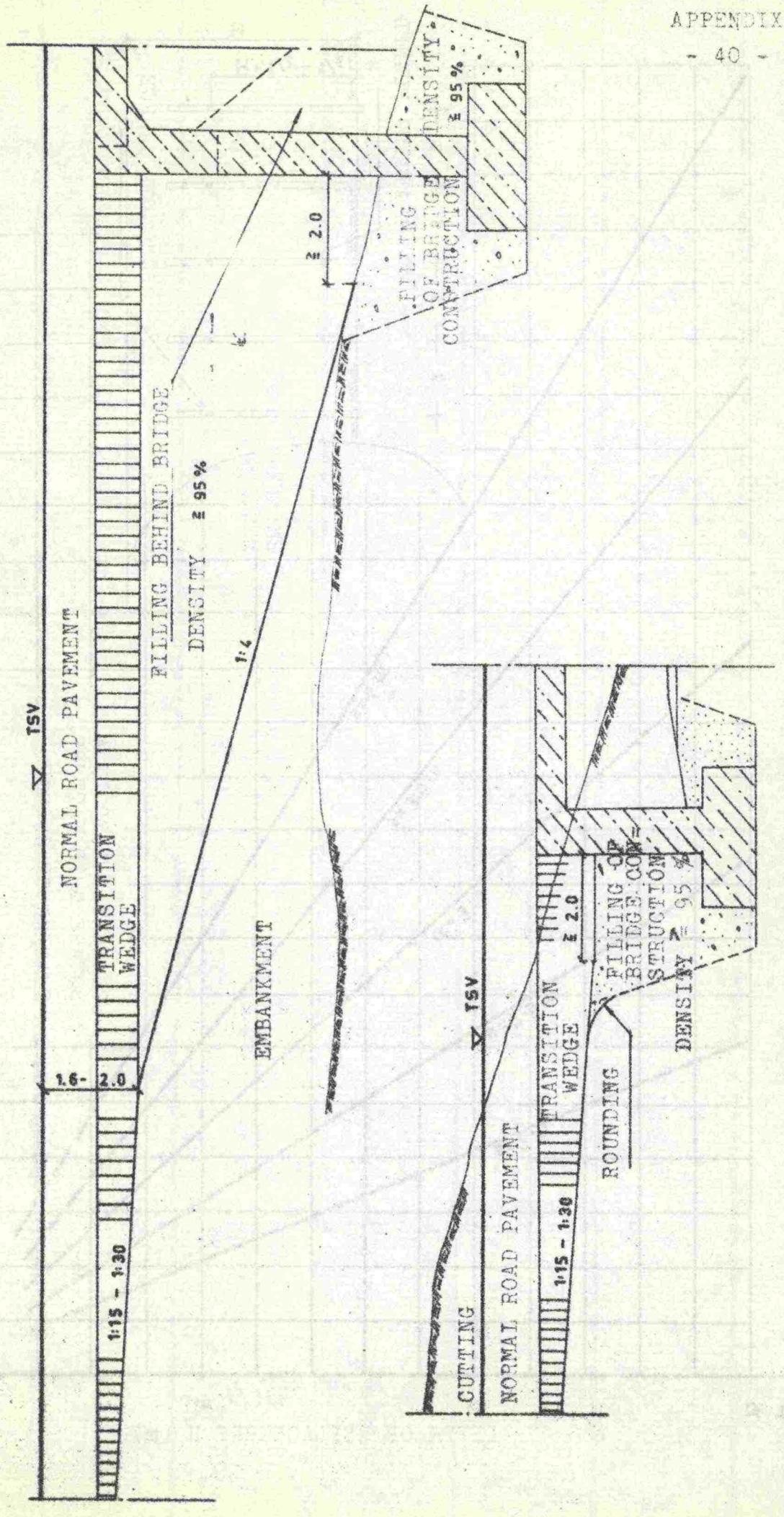
Ia: Under adverse conditions, the compaction and treatment of soils of this category are more difficult than in soils of the 1st category.

II: Even a small excess quantity of water above the optimum moisture content ($\geqq$ 2 %) will cause difficulties in the compaction of the soil. When the moisture content is near the liquid limit, the soil cannot <u>generally</u> be used as such as embankment fill. The stability of the embankment shall always be clarified. Soils are suitable for materials in the sandwich construction below the frost line and in stabilizing embankments. In general, the structure shall be faced immediately in order to prevent flowing caused by surface water erosion. Under favourable conditions, the workability of soils of this category may be improved by lime stabilization.

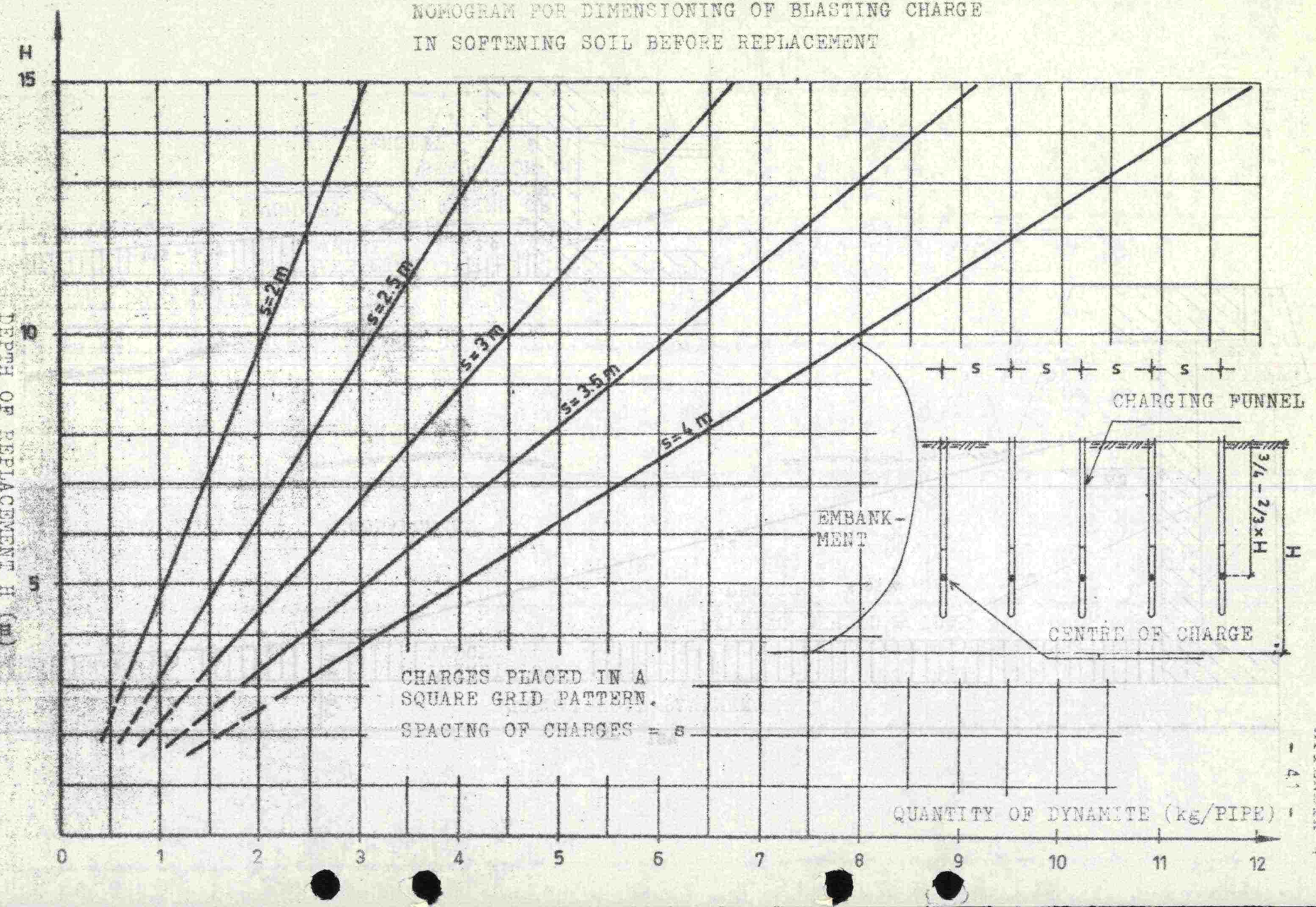


III: This soil type shall not generally be used as embankment fill except in stabilizing embankments. With special permission, dry crust clay may be used in the lower portions of embankments below the frost line provided that the moisture content of clay is sufficiently below the liquid limit and that the clay can be compacted in such manner that the stability of the embankment is ensured. Compacting clay is normally difficult. Under favourable conditions, the workability of clay can be improved by lime stabilization.

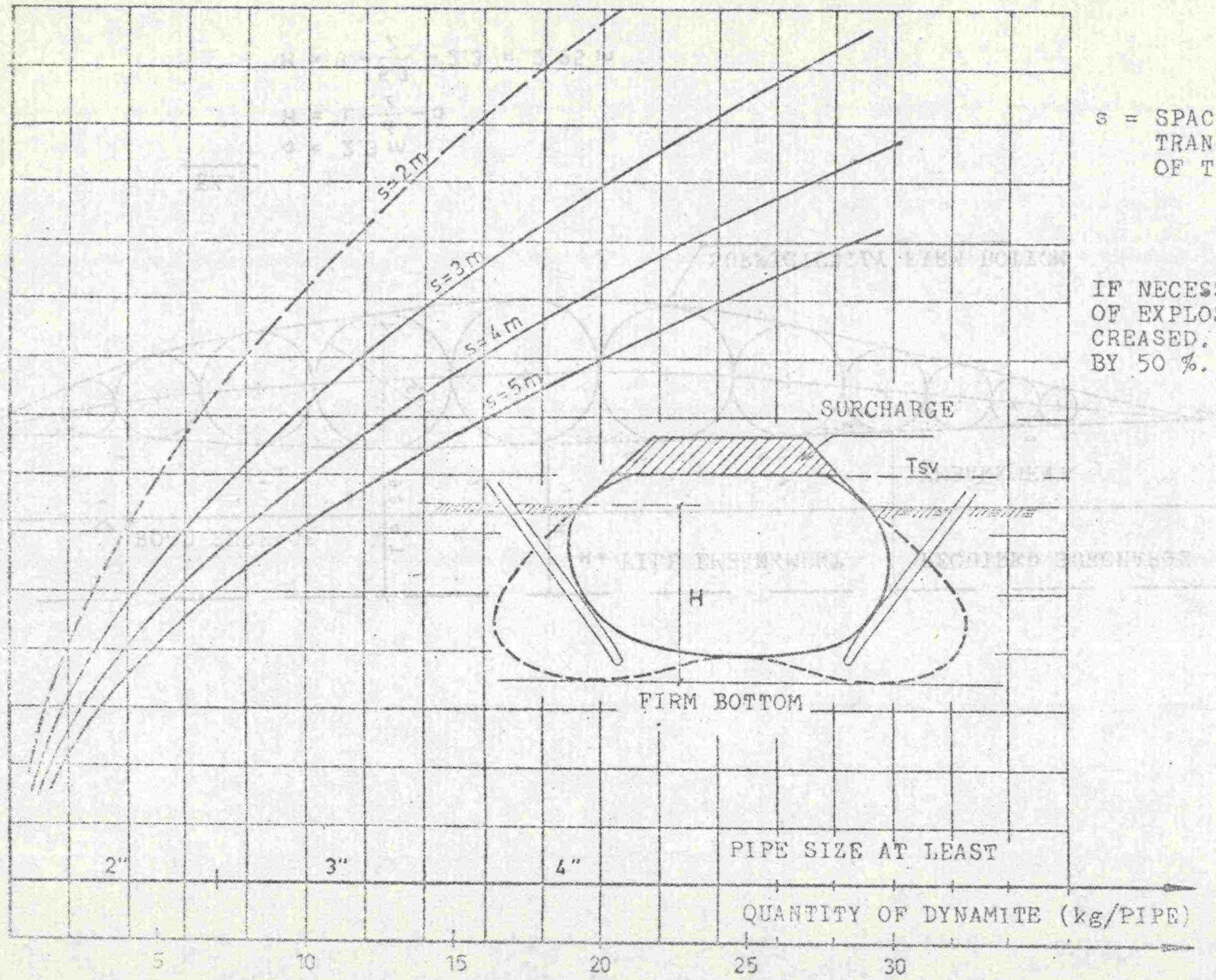
FILLING BEHIND BRIDGES



NOMOGRAM FOR DIMENSIONING OF BLASTING CHARGE IN SOFTENING SOIL BEFORE REPLACEMENT



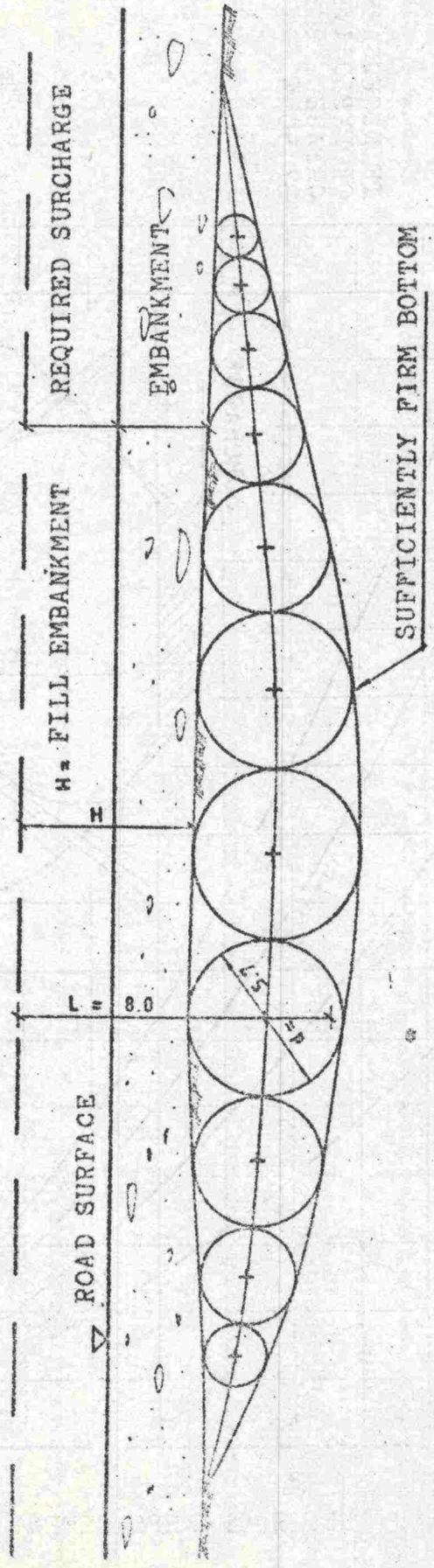
NOMOGRAM FOR DIMENSIONING OF CHARGE IN BLASTING AT SIDES OF EMBANKMENT



s = SPACING OF CHARGES IN TRANSVERSE DIRECTION OF THE ROAD

IF NECESSARY, THE QUANTITY OF EXPLOSIVES MAY BE INCREASED, BUT NOT MORE THAN BY 50 %.

DETERMINATION OF CENTRES OF SPHERE OF EXPLOSION



EX.

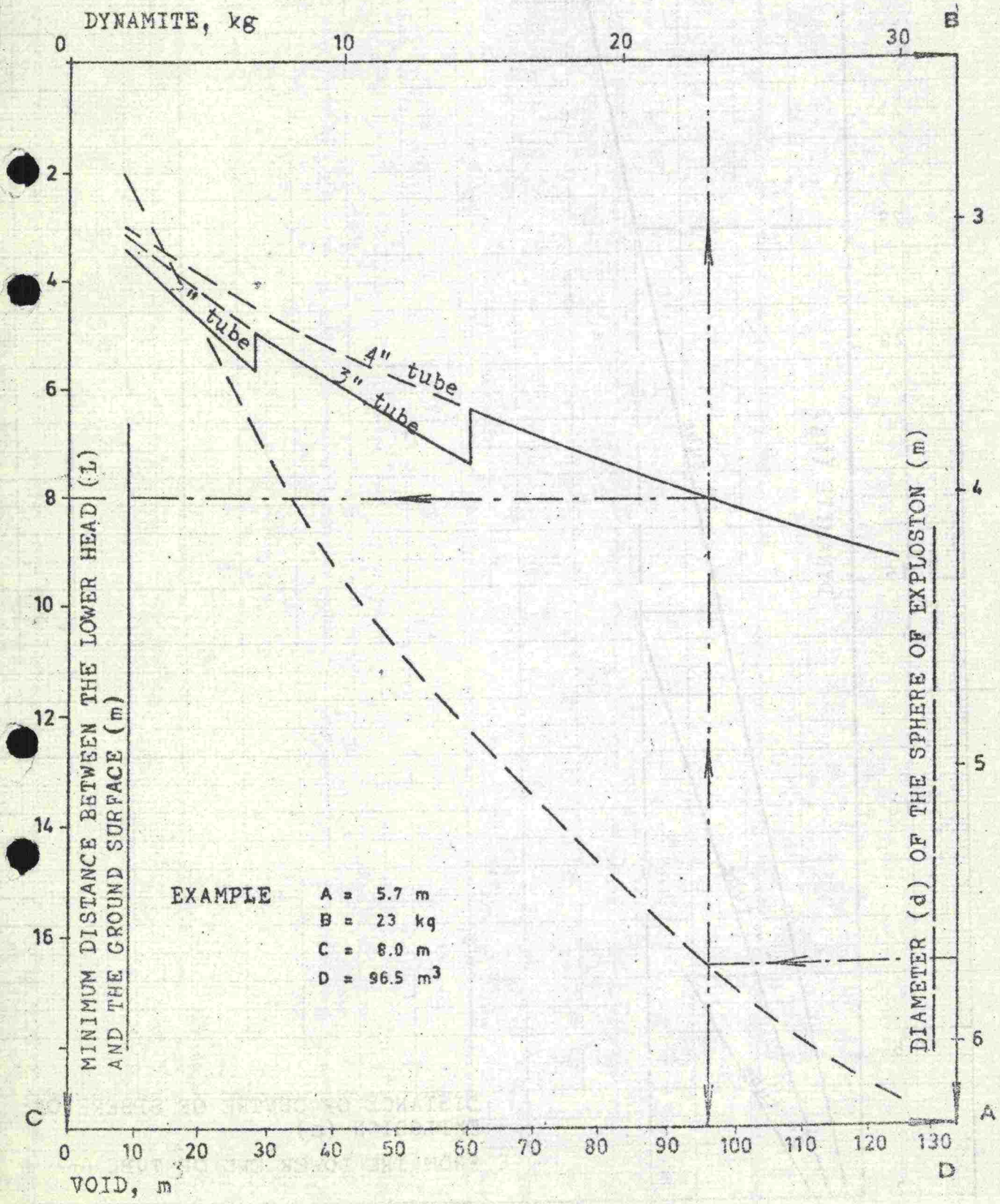
$a = 2.3\ m$

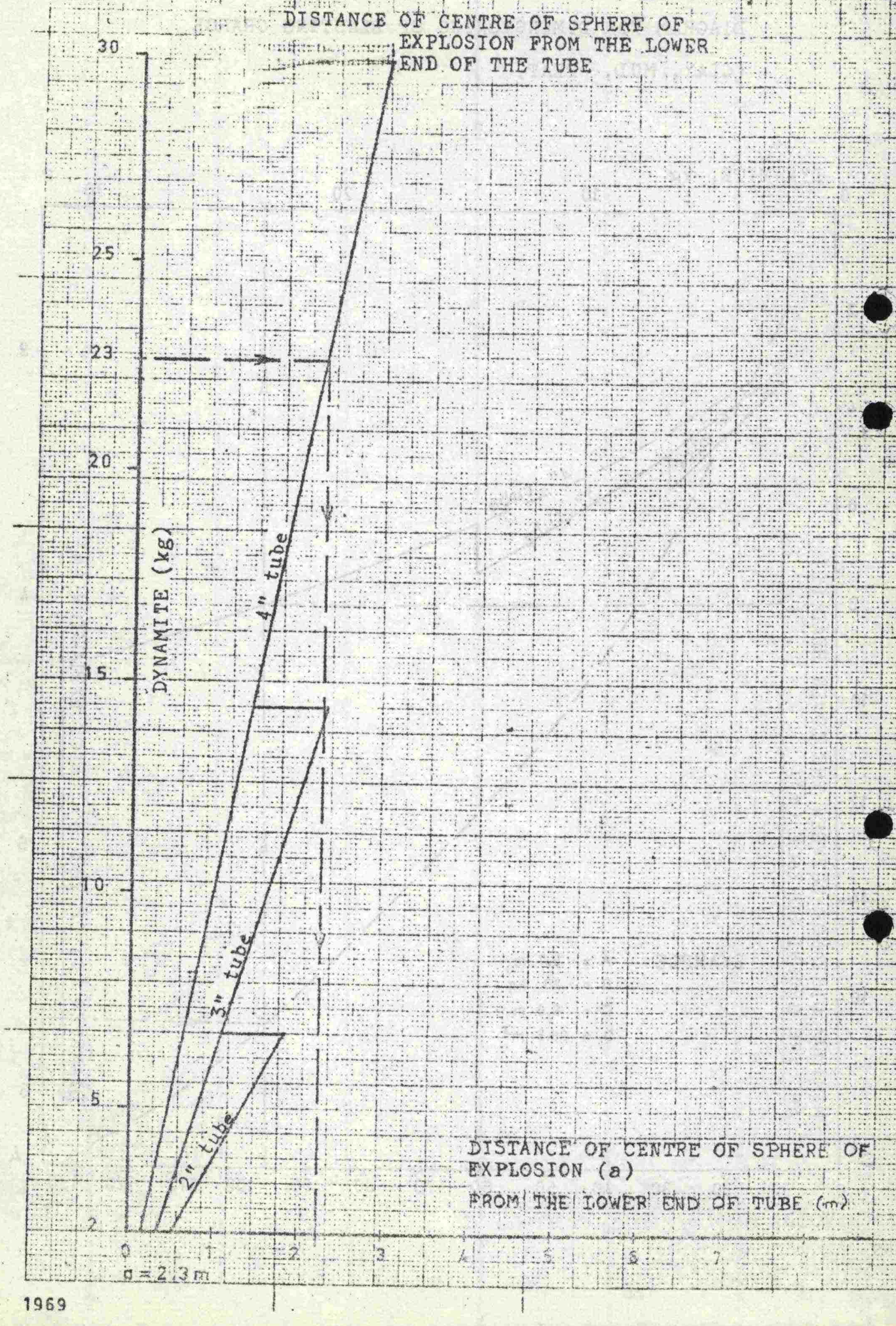
$H = L - \frac{d}{2} - a$

$H = 8 - \frac{5.7}{2} - 2.3 = 2.85\ m$

DIAGRAM FOR DIMENSIONING OF BLASTING CHARGE

(CLAY, MUD, PEAT)

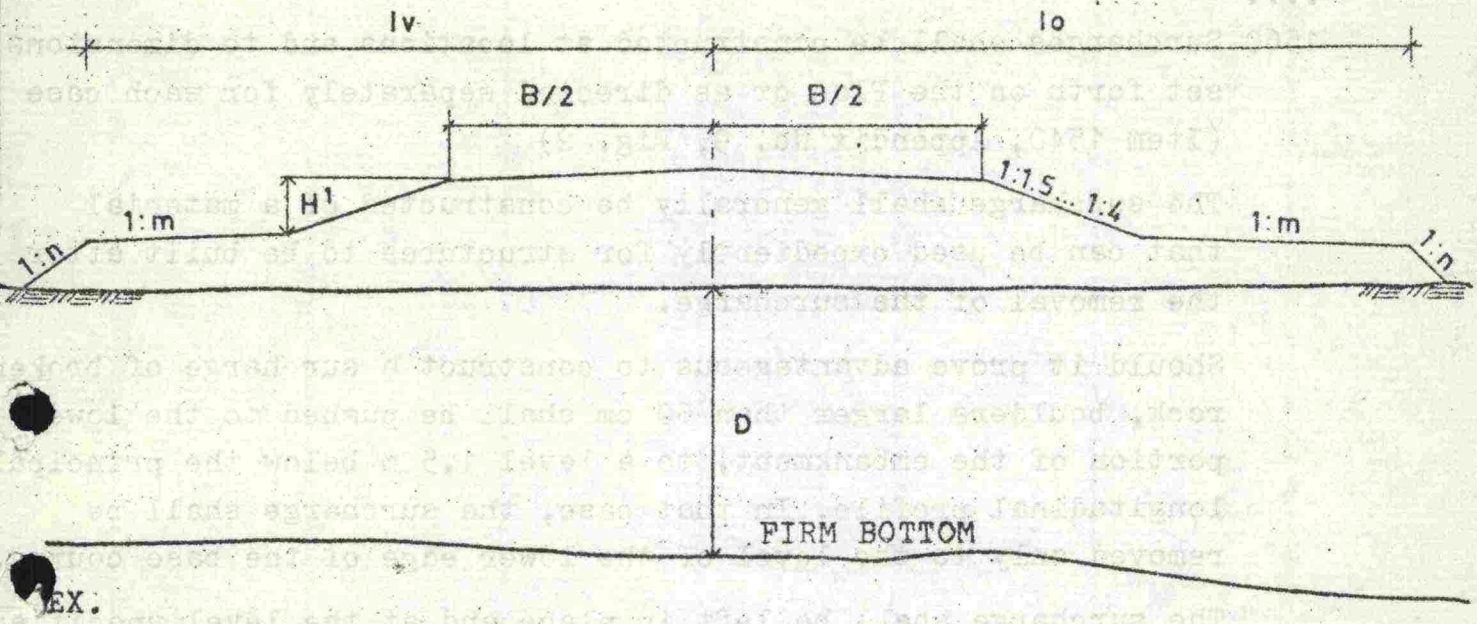



DISTANCE OF CENTRE OF SPHERE OF EXPLOSION FROM THE LOWER END OF THE TUBE
30
25
23
20
15
10
5
2
DYNAMITE (kg)
4" tube
3" tube
2" tube
DISTANCE OF CENTRE OF SPHERE OF EXPLOSION (a)
FROM THE LOWER END OF TUBE (m)
0
1
2
3
4
5
6
7
a = 2.3 m

1969

STABILIZING EMBANKMENT

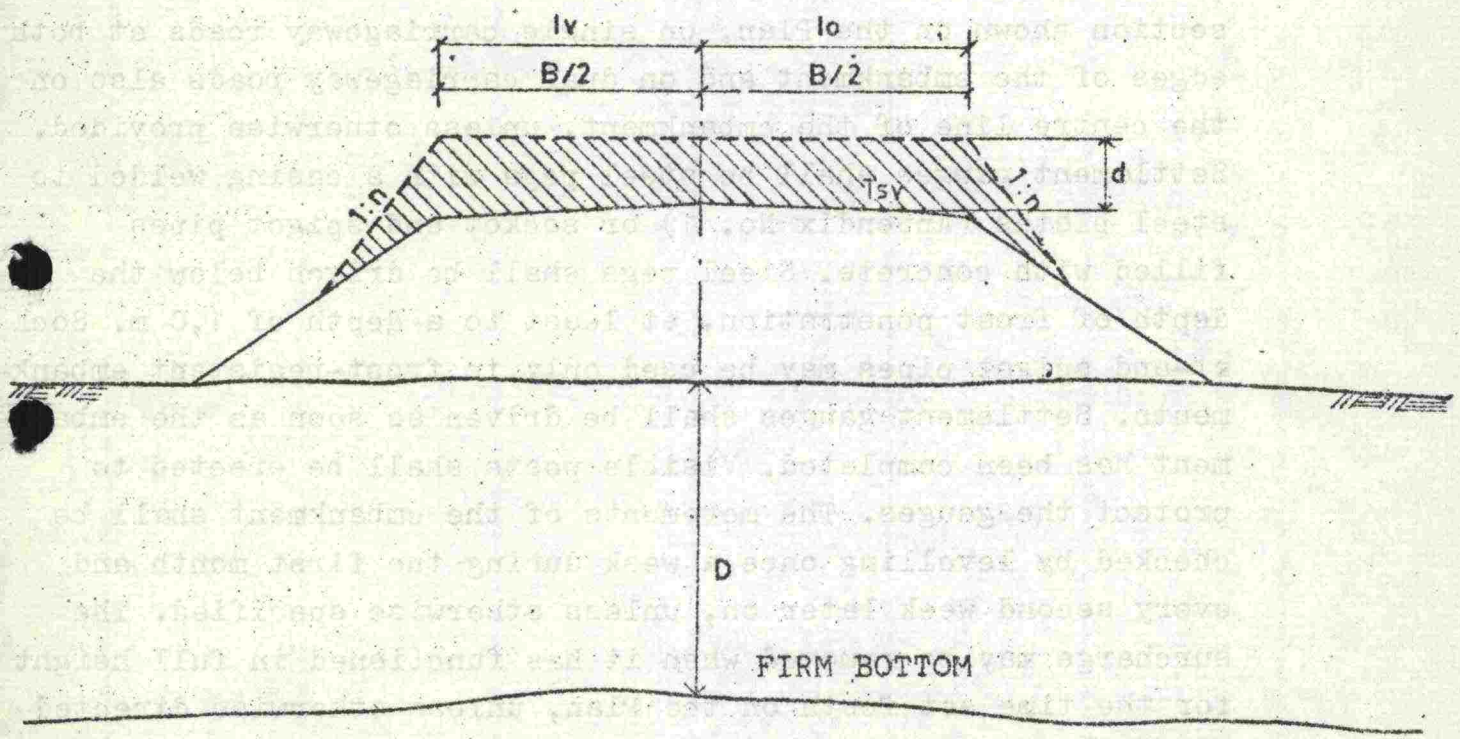
IG. 1



EX.

Ch.	lv (m)	lo (m)	H¹ (m)	m	n
0+00	8.3	9.2	0.7	20	1

FIG. 2



EX.

Ch,	lv (m)	lo (m)	d (m)	n
2+00	3.5	3.5	1.0	1

1550 CONSTRUCTION AND REMOVAL OF SURCHARGE

....

1560 Surcharges shall be constructed at locations and to dimensions set forth on the Plan or as directed separately for each case (Item 1540, Appendix No. 9, Fig. 2)

The surcharge shall generally be constructed of a material that can be used expediently for structures to be built after the removal of the surcharge.

Should it prove advantageous to construct a surcharge of broken rock, boulders larger than 60 cm shall be pushed to the lower portion of the embankment, to a level 1,5 m below the principal longitudinal profile. In that case, the surcharge shall be removed only to the level of the lower edge of the base course.

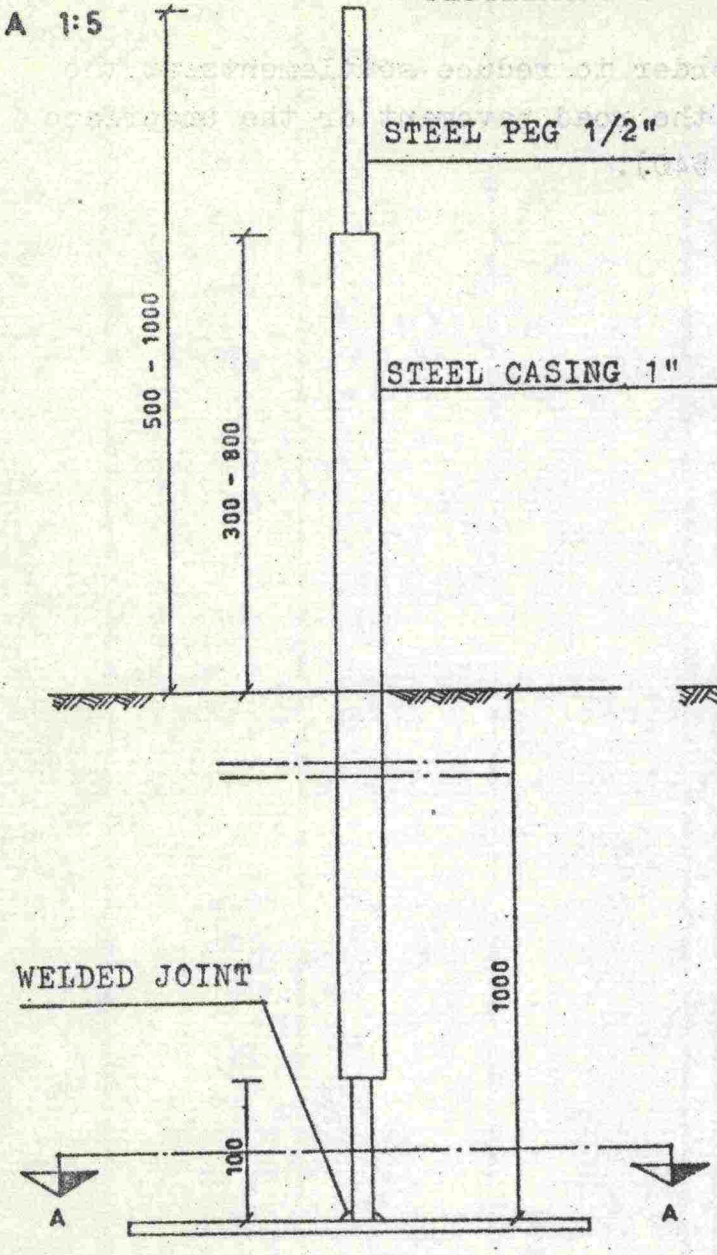
The surcharge shall be left in place and at the level specified on the Plan. The settlement of the embankment during surcharging shall be recorded. Should there be settlements during loading, the surcharge shall be kept at the level specified on the Plan. It is not necessary to raise the height of the surcharge before at some spot the settlement exceeds 20 cm. Settlement gauges shall be placed in the embankment at cross section shown on the Plan, on single carriageway roads at both edges of the embankment and on dual carriageway roads also on the centre line of the embankment, unless otherwise provided. Settlement gauges shall be steel pegs with a casing welded to steel plates (Appendix No. 1) or socket and spigot pipes filled with concrete. Steel pegs shall be driven below the depth of frost penetration, at least to a depth of 1,0 m. Socket-and spigot pipes may be used only in frost-resistant embankments. Settlement gauges shall be driven as soon as the embankment has been completed. Visible posts shall be erected to protect the gauges. The movements of the embankment shall be checked by levelling once a week during the first month and every second week later on, unless otherwise specified. The surcharge may be removed when it has functioned in full height for the time set forth on the Plan, unless otherwise directed on the basis of settlement control operations.

The above specifications shall be followed when applicable also in cases when a period of settlement has been determined

for a road embankment in order to reduce settlements at the level of the underface of the road pavement or the underface of the base course (Item 1540).

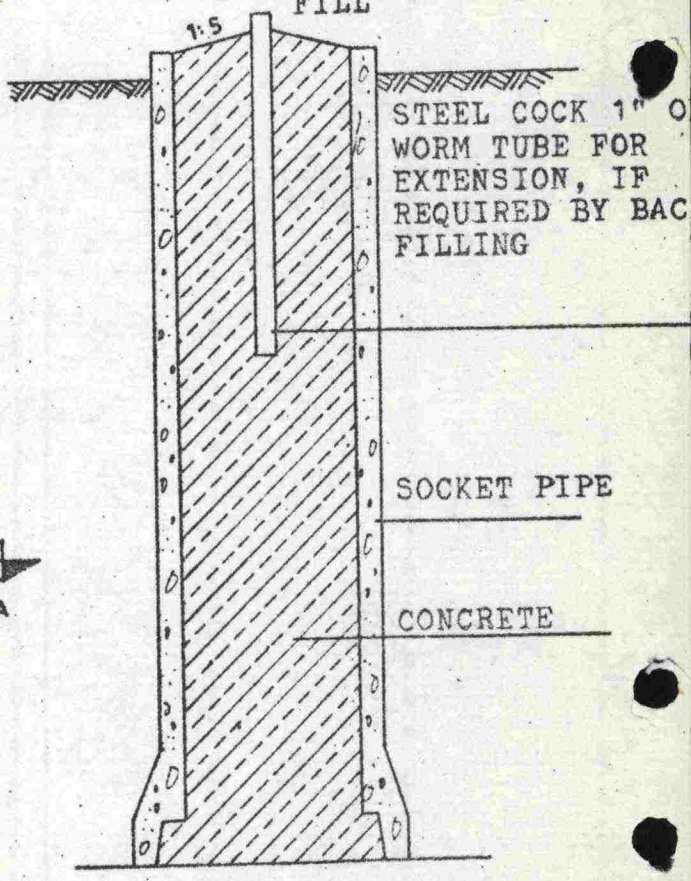
SETTLEMENT GAUGE

A 1:5

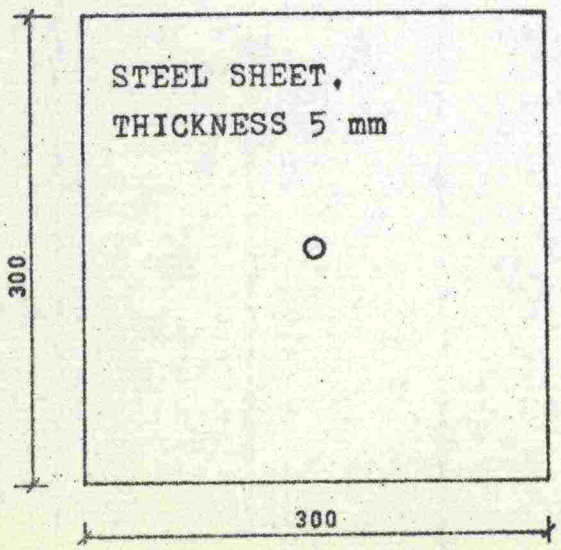


IN FROST-SUSCEPTIBLE FILL THE SHEET IS BASED BELOW FROST LINE

B 1:10 USED ONLY WHEN FILL IS FROST-RESISTANT FILL



A - A



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